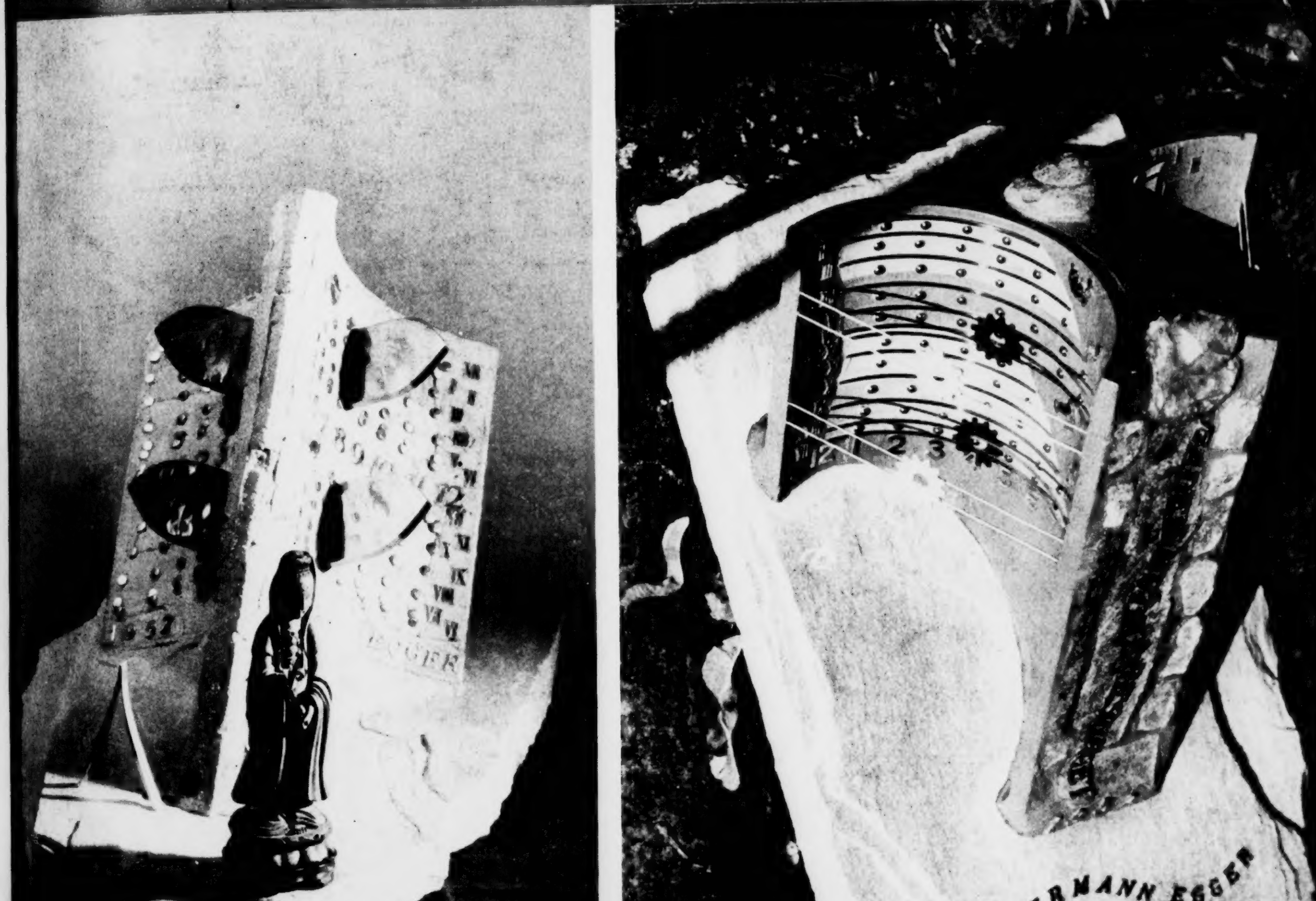
Sky and TELESCOPE



Modern sundials

l. XII, No. 9
JULY, 1953
le Number 141

In This Issue:

In Focus

DISTANT DENIZENS of the universe are portrayed this month on our back cover and on the supplemental center picture, from photographs taken by the 200-inch telescope on Palomar Mountain. These represent the systems, both nearby and distant galaxies, to which the generally accepted distance is double what we had formerly thought, as described by Dr. Otto Struve in the article on the scale of the universe that concludes in this issue.

The objects on the back cover are bright enough to be observed with good-sized amateur-made telescopes, and they represent various types of external galaxies. Most prominent is NGC 3190, a 12th-magnitude spiral of type Sb, which means it is intermediate between the least and most nucleated spirals, about like the Andromeda galaxy and probably like our own. Above and to its right is the elliptical galaxy NGC 3193, of type E2.

The most southerly object in the back-cover field (at lower left) is NGC 3185, a barred spiral of type SBa, looking something like a Greek letter theta. Another barred spiral, below NGC 3190, is NGC 3187, which is of type SBc, in which two arms appear to originate at opposite ends of a bar-shaped nucleus. This galaxy, faintest of the four, is of magnitude about 13.5.

On the new distance scale, this group is probably about 14 million light-years away.

Chart VIII of the Skalnate Pleso **Atlas of the Heavens** shows the positions of three of these galaxies (excluding NGC 3187), midway between Gamma and Zeta Leonis in the blade of the Sickle of Leo. Positions of the four galaxies in 1950 coordinates are: NGC 3185, $10^h\ 14^m.9$, $+21°\ 56'$; NGC 3187, $10^h\ 15^m.2$, $+22°\ 08'$; NGC 3190, $10^h\ 15^m.4$, $+22°\ 05'$; NGC 3193, $10^h\ 15^m.7$, $+22°\ 09'$.

Most of the objects seen in photographs of very distant clusters of galaxies, such as the remarkable Corona Borealis cluster on the center pages of this issue, are ellipticals; their compactness makes them easier to photograph than spirals even when they are extremely faint and distant. The position of this group, given by Hubble in **The Realm of the Nebulae**, 1936, is at $15^h\ 19^m.3$, $+27°\ 56'$ (1930).

This is a compact cluster; 100-inch telescope photographs show about 400 galaxies concentrated in an area of the sky about the size of the moon. The brightest member has an apparent magnitude (uncorrected) of 16.5, and the red shift of one bright member is about 13,000 miles per second. The adopted distance on the old scale was 125 million light-years; on the new scale it would be about 250 million.

The staples holding this picture may be opened and the paper removed for separate mounting or framing. Effects of the center fold may be reduced by careful work with a soft pencil. North is at the bottom. The scale of the reproduction is about 1 millimeter to 2".4. The photograph was made with the 200-inch telescope of Mount Wilson and Palomar Observatories.

Sky and TELESCOPE

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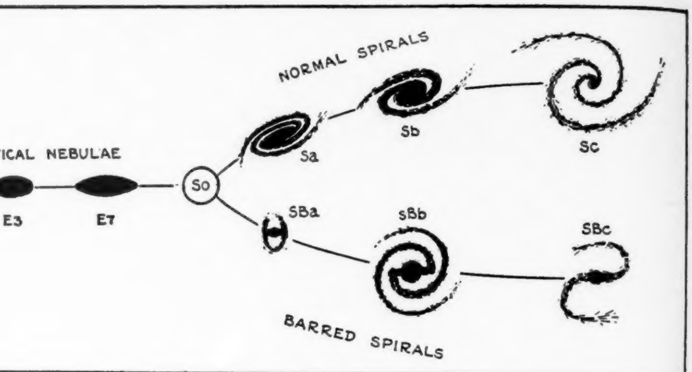

The classical diagram by E. P. Hubble of the types of galaxies. Objects on the back cover and the center picture may be compared with these types.

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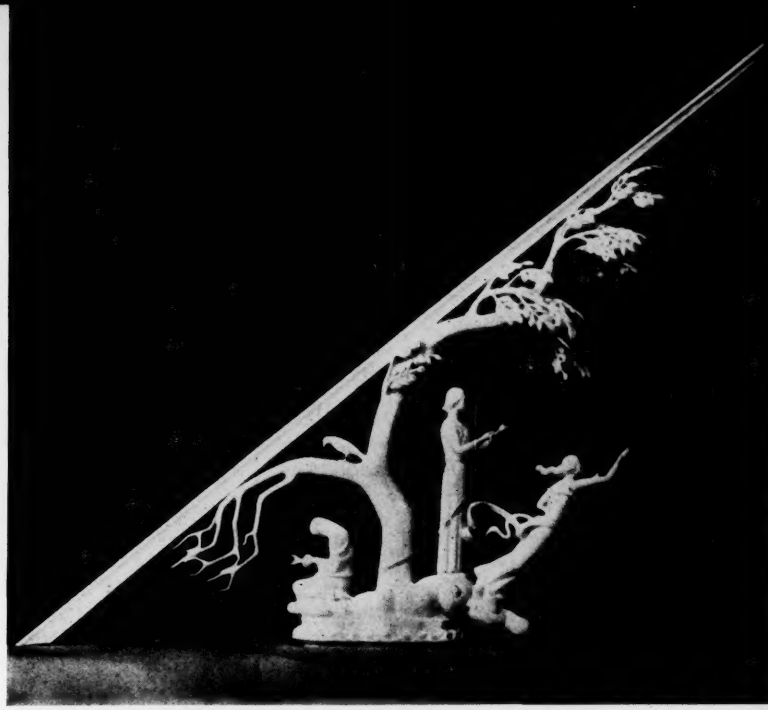
About Sundials

By H. Egger
Zurich, Switzerland



A model of a 50-foot sundial designed by Paul Manship for the New York World's Fair, 1939-1940.

IN A NUMBER of countries there has been a noticeable revival of interest in sundials, one of the oldest types of timekeepers. A modern sundial can be constructed to give the time for everyday use as accurately as any watch or clock. Our knowledge of mathematics and geometry has enabled us to develop formulae and designs for the construction of new types of sundials, such as those by the writer that are pictured on the front cover of this magazine. Working out new methods of design and experimenting with new sundial materials is a fascinating hobby.

Many thousands of years ago, prehistoric man noticed the phenomenon of shadows cast by upright objects, and no doubt he also observed that the shadow lengthened and shortened in relation to the position of the sun at different times of the day. The first primitive form of sundial was made when man placed a post or pillar firmly in the ground and marked the positions of its shadow with stones. As early as 2500 B.C., the Chinese were acquainted with this gnomon type of sundial; they used two stones to mark the meridian line which connects the shortest daily shadows of the sun, in order to find the longest and the shortest days in the year. In this way they discovered the fundamental dates of the seasons. Even today, sundials are in extensive use in some parts of China and Japan.

The first sundials on a scientific basis were constructed by the Greek astronomer Eudoxus and the Chaldean astronomer Berosus about 350 B.C. They were spherical dials, the hemispherium and the hemicyclium, hewn out of solid marble, with lines on an approximately circular arc showing the hours of the day and the three basic date lines: the shortest and the longest day and the line of the equinoxes. A Roman sundial of this type is illustrated here. A horizontal or perpendicular style was attached, the top of which was the actual center of projection of the rays of the sun.

This Roman sundial or hemicycle was made about A.D. 300 and is now in the British Museum, London.

These sundials were based on astronomers' observations of the movement of the sun in the sky, and already embodied the main features of a date sundial. During the Christian era the construction of sundials was successively developed and improved, as a result of more accurate observations of the sun.

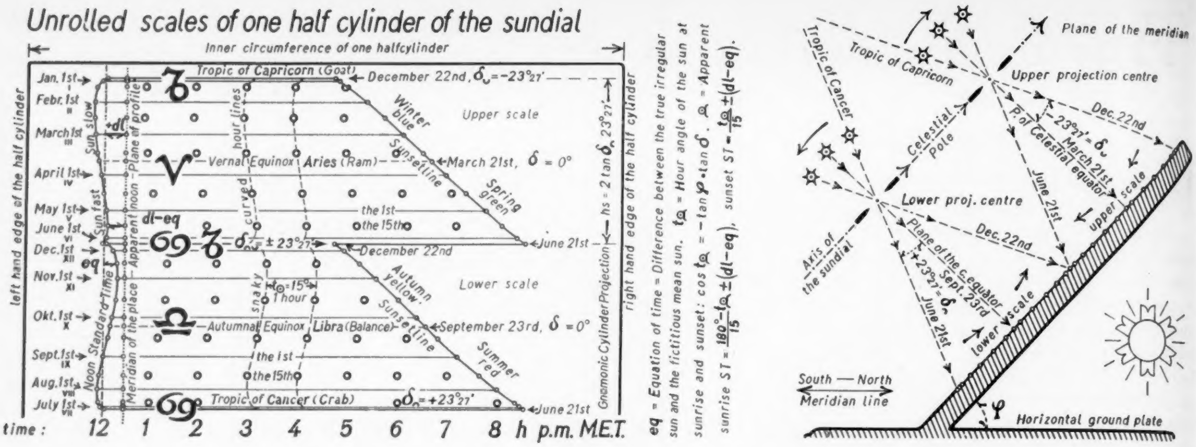
The style or gnomon should be mounted in a direction parallel to the earth's axis, in other words, it should point directly to the celestial pole. In its daily movement parallel to the celestial equator, the sun appears to revolve around the sloping edge of the gnomon, a basic principle that should be understood by anyone contemplating the construction of a sundial. This astronomical principle, already known to Eudoxus, is the basis of all trigonometrical formulae used in sundial design, such as those of the Arabian Albategnius about A.D. 900.

A remarkable sundial 90 feet high was built in 1724 by the Maharajah Jai Singh II of Jaipur, which still is the largest in the world, but shows only the sun's apparent time. When one is sitting on the curved surface of the dial, the movement of the sun's shadow can be conveniently observed, for it takes place at the rate of two inches per minute!

By taking into account the equation of time, mean time or civil time sundials were designed. The comparatively recent introduction of standard time and standard time zones has called for further revision in sundial design. Today, the growing interest in sundials not only offers architects full scope for displaying their creative abilities, but also inspires geographers and astronomers to calculate the most efficient scientific sundials, to show standard time from sunrise to sunset, whenever the sun is shining, as well as the date during the entire year.

On most sundials that show the date, the two different series of days (corresponding roughly to the first and second halves of the year) are marked on a single scale. This gives rise to confusion in reading, for the dates appear on the loop-shaped analemma that is a well-known feature of these dials. The ana-

The largest sundial in the world, built in 1724 at Jaipur, India.



Details of the afternoon reading face and of the operating principles of the author's gnomonic cylinder sundial.

lemma takes account of the equation of time, the difference between local mean and apparent sun time, but its parts do not match each other for corresponding parts of the year.

By using two centers of projection, the 12 months of the year may be represented on two separate scales. Thus, the upper scale of each of the dials on our front cover refers to days from the winter solstice to the summer solstice, while the lower scale applies from the summer to the winter solstice. The lines marking the hours are curved single lines, permitting the time to be read off easily, for each series of days has its own separate concave scale and separate projection center.

When the sun's rays are projected on horizontal, vertical, or inclined planes, the date lines are hyperbolic curves and the spaces between the hours vary considerably, narrow at midday and wider toward morning and evening. This deficiency can be overcome by using a dial in the form of a concave cylinder. Now the distances between the hour marks are constant, provided the axis of the cylinder is parallel to the axis of the earth. But as the sun during half of the year passes through an angle of more than 180 degrees while it is above the horizon, it has been necessary to split the cylinder into two parts, one facing the morning half of the sky, the other the afternoon half. This results in quite a novel type of sundial as a unit, with four centers of projection, as shown by both of the dials on the front cover.

The center of the shadow of each point of projection thus marks the hour and the date, while the straight shadow of the edges of the cylinders has no time-measuring function. On the right-hand dial, the four scales are constructed in accordance with the gnomonic cylinder projection, with which is obtained rectangular representation of the meridians (hour lines) and parallels of declination (date lines).

The sundial pictured at the left on the cover is designated by me to be of an "intermediate cylinder" type, for the twin points of the four styles lie halfway between the axis and the cylinder, giving a more "open" appearance than in the sundial at the right, where the projection points are on the central axis of each cylinder. This, however, does change the date lines from the parallel circles of the pure gnomonic form (the right-hand dial) to wavy curves.

This pillar sundial at Corpus Christi College in Oxford, England, was constructed by C. Turnbull in 1581. It gives the sun's apparent time; the hour lines and the date line of the equinoxes are ellipses.

The gnomonic sundial is made of green sericite stone. The four different seasons are represented on each half cylinder in colors: spring in green, summer in red, autumn in yellow, and winter in blue. Winter and spring are shown on the upper scale; summer and autumn on the lower scale. The details of these are shown in the accompanying diagram. The golden signs of the zodiac glistening in the sun are visible in high relief above the sunrise and the sunset lines. The Roman numerals along the edges of the cylinders and the parallel circular curves in silver, marking the path of the projected disk of the sun's rays, indicate the first day of the respective month. The Arabic numerals at the lower end of the dotted hour marks show the hours in standard time.

The markings of any type of polar sundial, plane or cylindric, are independent of the latitude at which the dial is set up. It is only the inclination of the axis of the dial in relation to the horizon that will alter with the latitude. Thus, at Hamilton, Ontario, the angle the axis makes with the horizon is a steep 43 degrees, while at Miami, Fla., the dial should be mounted at 26 degrees. At the north pole, the axis and scale would be vertical, whereas at the equator, the dial would be in a horizontal position.

It is customary to place an inscription on sundials, such as the name of the person to whom the dial is dedicated, or a Latin quotation, preferably connecting the aspects of human life with the cosmic passage of time. One might use a verse, such as:

See the little daystar moving—*
Life and time are worth improving,
Seize the moments while they stay:
Seize and use them,
Lest you lose them,
And lament the wasted day.

*Daystar: the spot of light on the sundial indicating the hour.

The Green Flash at Sunset and at Sunrise

By T. S. Jacobsen, *University of Washington*

Due to increasing differential absorption of light of different wave lengths in the earth's atmosphere, the color of the sun becomes redder as it approaches the horizon. On quiet, clear days with but little haze in the atmosphere, the last rays from the sun's narrow segment, setting behind a sharply defined, smooth and distant horizon, will nevertheless not be red or orange, but either yellow-green, green, blue-green, blue, or blue-violet. The last trace of direct sunlight will for a short interval, usually a fraction of a second, form an intensified spark or flickering glare whose spectrum contains a strong region a few hundred angstroms in width, lending a quality of purity to the hue observed. At sunrise the spark precedes the appearance of the white solar limb by a small interval.

During 1951-52, I succeeded in observing three naked-eye flashes colored yellow-green, green, and blue, respectively, and in addition eight faint flashes or final sunset glares invisible to the naked eye but spectacular in a 7-power binocular. The 11 observations alone include every color mentioned above, and also, in one case, a distinct yellow coloration of the solar edge for one final second preceding a very red sunset. Blue is undoubtedly a precise description of the color of the best flashes seen in certain favored localities, and recently "the blue flash" has been used as the title of two articles on this phenomenon. Nevertheless, it seems to me that, unless we were to use the term "colored flash," it would be best to retain the well-known and historically accepted term, the *green flash,* to denote the general phenomenon.

Most of the literature on the green flash, although belonging to meteorological optics, has appeared in astronomical journals. One of the best summaries, containing references to 178 items connected with the subject, is given in an article by Willard J. Fisher in *Popular Astronomy* for 1921 (Vol. XXIX, pages 251, 382). He lists 44 observations of the flash made by himself, chiefly from Manila, and 55 by others in various parts of the world. Descriptions of color, duration, and appearance of each flash are appended, showing the great diversity and capriciousness of the phenomenon, which may range from a hardly noticeable yellow pulse of light to a brilliant flicker like an arc light, colored emerald green, sapphire blue, or bluish violet. The smallest flashes can only be observed with optical aid.

The study of the green flash by means of scientific instruments has not progressed very far because of the difficulty of training them on such an elusive phenomenon. In 1920, Danjon and Rougier, using a one-prism spectrograph with a large collecting lens mounted on the flat part of the roof of the cathedral of Strasbourg, photographed the spectrum of the green and red fringes, exposing the plates up to two minutes immediately preceding sunset. They found that the spectrum of the green fringe is in all respects identical with that of the center of the sun's disk exposed at the same altitude, except for a suppression of the red. This, of course, gives no information about the spectrum of the flash, as the sun was not actually setting, but merely at low altitude, and their exposures were much too long.

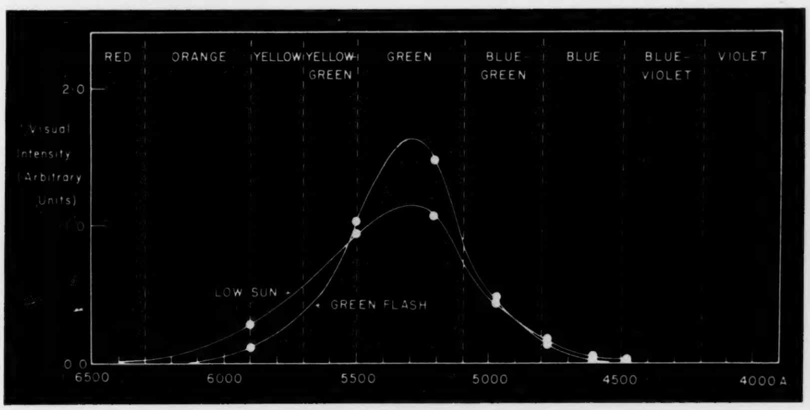
Nevertheless, according to Danjon and Rougier, atmospheric dispersion causes a spectrum in which the colors are arranged vertically, red below, violet above. Near the horizon, the red is separated from the orange by the atmospheric tetratomic oxygen absorption band at wave length 6310 angstroms. The orange is almost entirely suppressed by the rain band at 5925, especially with a moist atmosphere. The yellow is reduced to a very narrow luminous strip lying between the orange rain band and two overlapping absorption bands, namely, the strongest Jansen band, due to tetratomic oxygen, and the rain band near 5732. A distinct but less intense separation occurs between the blue-green and blue at the tetratomic oxygen band near 4775. The boundary between the blue and violet is faintly but distinctly marked by the Fraunhofer G line, a group of strong iron lines at 4308 angstroms.

The commonly accepted wave lengths of the colors easily perceived by the normal human eye are: red, 7500-6300; orange-red, 6300-6000; orange, 6000-5900; yellow, 5900-5700; yellow-green, 5700-5500; green, 5500-5100; blue-green, 5100-4800; blue, 4800-4500; blue-violet, 4500-4200; violet, 4200-4000.

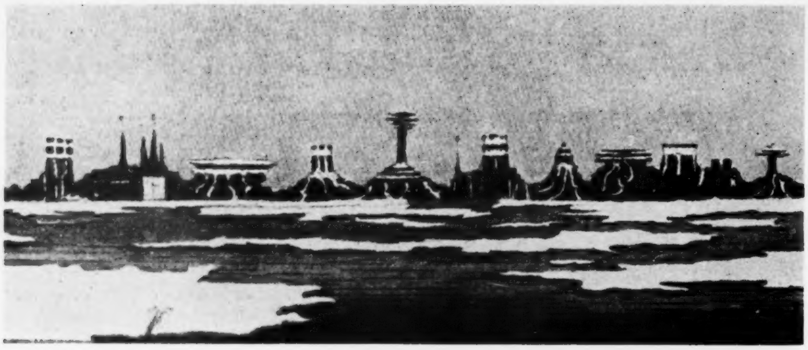
At sunset, everything proceeds very much as if the sun's image consisted of a series of nearly monochromatic disks, displaced slightly in altitude with respect to each other, red below, violet above. The air normally absorbs the blue and violet, except at high altitudes above sea level or with an unusually transparent atmosphere. As the sun descends toward its setting point, a bluish green fringe forms on the upper edge of the yellow disk. Similarly, the lower limb is bordered by a red fringe. In powerful instruments, such as the Mount Wilson tower telescopes, the blue-green fringe may be distinctly observed at least an hour before sunset. With 7-power binoculars and a quiet solar image it becomes easily visible, in consequence of the decreased general illumination, when the solar disk has set by about two thirds of its diameter. When this is the case, it is practically certain to be followed by a good flash at sunset, if the horizon is smooth and sharply defined.

According to M. E. Mulder (in whose book of 1922 reference is made to an autochrome photograph of the green flash taken prior to that time), the green flash is "the development and final disappearance of the green fringe on the upper limb of the sun." The development may be seen in a binocular, and normally proceeds as follows:

When the narrow yellow segment, a few seconds before complete disappearance of the sun, becomes so thin that it appears to the naked eye as a short straight line widened by irradiation, the binoculars still show it as a very small



The visual spectral intensity curve of the green flash, compared with that of the low sun; at 5300 angstroms the green flash is much more intense.



Irregular atmospheric refraction and dispersion influence this telescopic appearance of the coast of Greenland, as seen from a distance of 35 miles, on July 18, 1920. Inversion layers over relatively hot or cold areas caused the mirages, towerings, and stoopings. The latitude was 71° 20′ north, longitude 17° 30′ west.

segment of a circle bordered on top by a luminous green arch touching the horizon at both ends. At the setting of the red disk (lowest of those described above), the yellow segment takes on a purer hue and suffers a sudden slight reduction of intensity, like that of an electric lamp regulated by slightly shifting the setting of a rheostat.

At about this time, or a little sooner, intense green buttons of light appear where the green arch touches the horizon. In the course of a couple of seconds these two sparks approach each other along the horizon, like sparks running along a fuse. If small, they scintillate. They grow in length as they reach the flatter portion of the arch, accelerate their rate of approach, and coalesce at the top of the arch, giving rise to a flash at the instant of the arch's disappearance.

The final setting of the green fringe does not immediately follow the setting of the yellow segment, but is retarded by whatever interval it takes the dark fringe corresponding to the two intervening absorption bands (the strongest Jansen band and a rain band near 5732) to disappear below the horizon. This causes a decrease of intensity of the yellow-green during the development phase of the green fringe into a flash, which helps to increase the impression of the suddenness with which green follows yellow; the fully developed flash also seems more intense. The spark is caused by the green fringe being lowered into the lowest atmospheric inversion layer where, alone, it shines through with increased brilliance and intensity. The yellow, orange, and red "disks" are gone; the blue and blue-violet are dimmed by selective absorption.

We might reserve the designation, *major flash,* for this phenomenon when there is an actual increase in the intensity of the last colored light. *Minor flash* might be used for the much more common case in which the green fringe, disappearing behind a horizon not overlaid by an inversion layer, attains no increase in brightness, but nevertheless by the suddenness of its isolation appears as a distinct "bead" of green light of about the same intensity as the yellow bead just preceding.

According to Fisher, the conditions necessary for an intense flash are a clear atmosphere, a free water line, and an inversion layer such as to produce the common mirage over warm water. This requires that a relatively warm layer of air next to the water surface be surmounted by a layer colder than its normal adiabatic temperature for its height. Under these conditions the intensity of the flash may be almost doubled by "reflection" in the apparent horizontal "mirror" just above the water surface, an effect often seen above the hot surface of a highway or a desert.

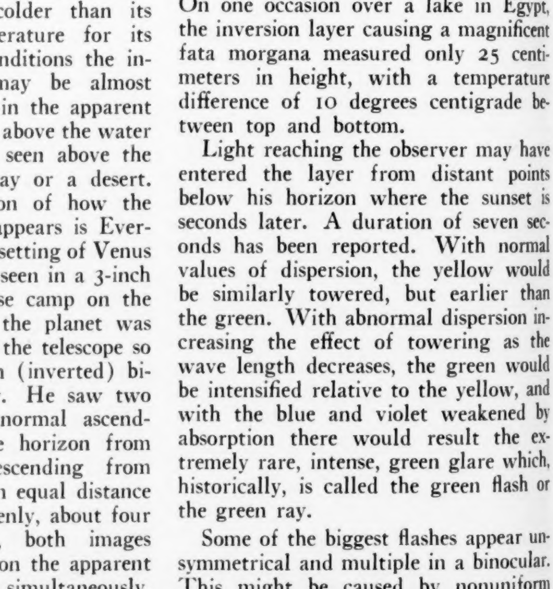
The classic illustration of how the doubling of the image appears is Evershed's observation of the setting of Venus over the Mediterranean seen in a 3-inch telescope from his eclipse camp on the Algerian coast. When the planet was about to set, he pointed the telescope so the image of the horizon (inverted) bisected the field of view. He saw two images of Venus, the normal ascending at an angle to the horizon from below, the mirage descending from above, keeping always an equal distance from the horizon. Suddenly, about four seconds before setting, both images turned green, then met on the apparent horizon and disappeared simultaneously. On that night the planet obviously did not set on the objective water horizon, but on the inversion layer produced by the air layers close to it.

At the equator, with the sun at one of the equinoxes, the duration of the flash itself, not including its development stage, should be about two thirds of a second, the time required for the green fringe (of width about 10 seconds of arc) to set. At other seasons or in higher latitudes the flash should last considerably longer. Members of Byrd's expedition to the South Pole are reported to have seen it for 35 minutes while the sun, rising at the close of the long winter night, was seen to be moving almost exactly along the horizon.

Even in the tropics, the duration of the flash is often more than two thirds of a second, due to many and often great irregularities of refraction along the path of the light ray near the horizon. The water horizon, the desert, a rock, or even a sharp-edged cloud behind which the setting takes place may be surmounted by an inversion layer whose index of refraction for green increases upward relative to its normal gradient. The green fringe will then appear sooner, be widened by *towering,* look more intense, and set later than predicted for normal conditions of dispersion. On one occasion over a lake in Egypt, the inversion layer causing a magnificent fata morgana measured only 25 centimeters in height, with a temperature difference of 10 degrees centigrade between top and bottom.

Light reaching the observer may have entered the layer from distant points below his horizon where the sunset is seconds later. A duration of seven seconds has been reported. With normal values of dispersion, the yellow would be similarly towered, but earlier than the green. With abnormal dispersion increasing the effect of towering as the wave length decreases, the green would be intensified relative to the yellow, and with the blue and violet weakened by absorption there would result the extremely rare, intense, green glare which, historically, is called the green flash or the green ray.

Some of the biggest flashes appear unsymmetrical and multiple in a binocular. This might be caused by nonuniform towering conditions along the horizon.



Diffraction camera spectra by P. Sinkey, enlarged about seven times. The low-sun spectrum (A) was taken 29 seconds before that of the green flash (B). Note the suppression of yellow, orange, and red in the green flash.

The sun's disk setting behind one or more maxima might give rise to as many flashes along the short line of the horizon illuminated by the green fringe, developing in irregular succession. Considering a distribution of inversion layers one behind the other, caused perhaps by currents, reefs, cold air masses, or other disturbing conditions far beyond the horizon, we may admit the possibility of retarded flashes of different intensities and durations, as the last sun rays wind their way through these "atmosphere lenses."

The first instrumental proof that the color of the flash is not a physiological illusion caused by fatigue or afterimages appeared in 1936, when N. Dijkwell published an article on his visual observations of several flashes seen through a prism. The last color seen was always a narrow region of green, as proved by its *position* in the spectrum, not by an estimate of its hue.

A study of the intensity distribution in the diffraction spectrum of a flash seen from the Kona coast of Oahu Island and recorded on a color film in 1950 by P. Sinkey was recently made by the author. For comparison, the spectrum of the low sun photographed on the same film 29 seconds earlier was subjected to the same analysis by means of green extractions and microphotometric measurements. Granting certain plausible assumptions regarding the uncalibrated photographic material, it was concluded that this particular green flash was accompanied by an intensification of green light relative both to other colors in its own spectrum and to the amount of green present in the low sun spectrum. The statement by Nijland (referred to below) that his brilliant sunrise flash was of a vivid green color corresponding approximately to an effective wave length of 5300 angstroms is in good agreement with the derived visual intensity curve of the Kona sunset flash.

Success in observing the green flash varies with the years even at the same station. The late R. G. Aitken stated in 1939 that it was seen by him from Mt. Hamilton, presumably with the naked eye, on 20 evenings in 1929. On other occasions when conditions were equally favorable, he watched for it every evening for more than a month and failed to see it at all. The phenomenon has been observed over both ocean horizons and land horizons, and occasionally at the upper edge of a low-lying, sharply defined cloud. It may be seen, if only once in several years, from practically all latitudes and longitudes, but the frequency and splendor of its manifestations varies enormously with geographical location.

Nijland, in Holland, saw a sunrise flash as a splendid emerald green ray, strong as a "go" sign for two seconds, then turning to a more yellow glare, four minutes of arc high, for 13 more seconds. Minnaert described a sunset flash which he kept in view for 20 seconds by running (backwards?) up a gently sloping dike while watching the sunset. The color fluctuated between bluish green and yellowish green according to variations in his pace, which moved his eye closer toward the blue if retarded, toward the yellow if accelerated with respect to the constant rate necessary to

PHOTOGRAPHS OF THE SUN'S CHROMOSPHERE

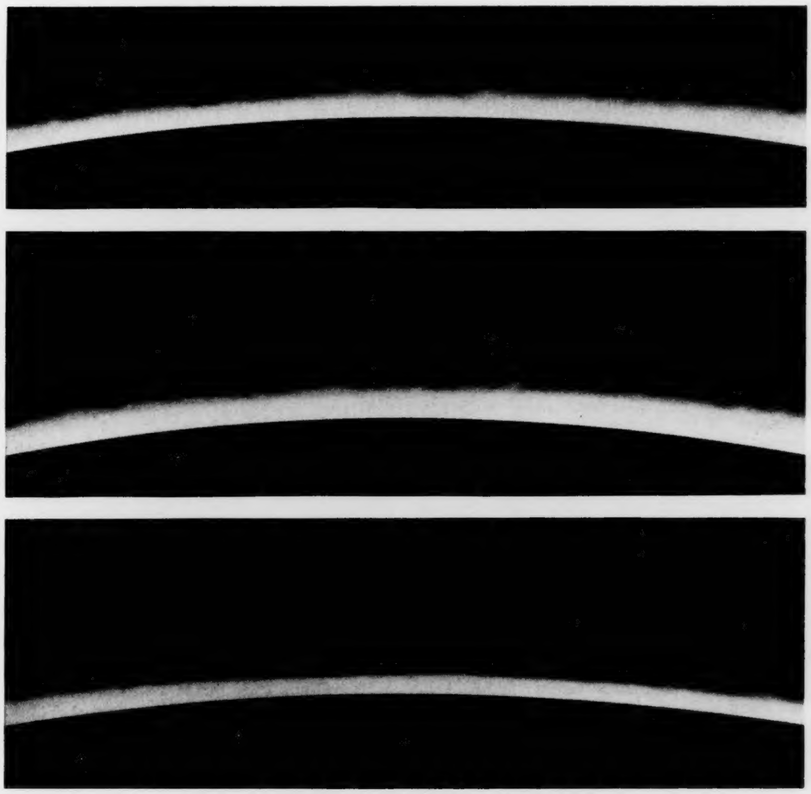
IN RECENT YEARS astronomers have become greatly interested in the motion of matter in the solar chromosphere. Some believe turbulence to be the key to many solar problems, others that some kind of jet action operates to furnish energy to the solar corona and maintain its extremely high temperature. The phenomenon of solar granulation and the more conspicuous solar prominences are probably all linked to action in the chromosphere.

The accompanying pictures show the chromosphere, some prominences, and a portion of the photosphere (the opaque surface of the sun itself). The dividing layer between the fuzzy irregular chromosphere and the brilliant photosphere appears as a distinct line that is sharper in some cases than in others. The angular height of the chromosphere is about 10 seconds of arc, less than the apparent diameter of Saturn. The rest of the photosphere has been occulted by a disk in the telescope.

In the upper picture, groups of spicules can be seen jutting upward at various angles with respect to the solar radius. A few spicules can be seen near prominences. The nature of the spicules was pointed out by Dr. Walter O. Roberts, of the High Altitude Observatory, in 1945.

When photographing the chromosphere, one must wait for moments of good solar seeing to get pictures that are not blurred. These were taken by Richard B. Dunn during the past year, with the Harvard Observatory 15-inch visual refractor in hydrogen-alpha light, through his 4.5-angstrom birefringent filter. With a projection eyepiece, the sun's image on the film was 7.2 inches in diameter. The exposure in most cases was 1/50 of a second on Hα film.

Mr. Dunn is the author of the series of articles, "How to Build a Quartz Monochromator for Observing Prominences on the Sun," that appeared in *Sky and Telescope*, Vol. X, 1950-51, which is now available in reprint form.



The edge of the sun's disk, photographed with a quartz polarizing monochromator by Richard B. Dunn, in the light of the hydrogen Balmer line at 6563 angstroms. Harvard Observatory photograph.

keep the green continuously in sight.

According to Rear Admiral Kindell, strong and brilliant flashes were seen by him and other members of the U. S. Navy during the Okinawa campaign of 1945 at almost every sunset on clear days. Also, on the ocean near Saipan flashes were seen "as bright as the full reflection of sunlight from a car windshield at three or four miles." All these flashes were of "an electric blue color, like the spark seen when a trolley jumps the wire." Possibly the conditions most favorable to a good flash in short wave lengths, clear moist air and strong inversion layers, are often fulfilled in the extreme western Pacific frequently swept by cold fronts from the Asiatic continent. A recent article mentions the coast of Algeria and Tunis, another very clear region, where the flash at its best has a bluish green tinge. To see it requires the observer to keep "a superlatively alert watch focused on the sun's upper rim as it dips below the horizon."

Egyptologists have often seen the flash in the dry land of the Nile and state that the ancient Egyptians were familiar with it. They believed it to come from the underworld, and therefore, it is said, mummies were fittingly colored green. According to other superstitions the green ray actually shines out of paradise and therefore reveals the true color of hope.

Amateur Astronomers

Southeast Region Holds Successful Convention

The Southeast region of the Astronomical League met on May 15th and 16th at the Clarence T. Jones Observatory of the University of Chattanooga, in Tennessee, celebrating at the same time the 30th anniversary of the Barnard Astronomical Society.

The Friday evening session was open to the public, and was held at the Interstate Building; about 150 people attended. A history of the Barnard society was given by Dr. J. Park McCallie, headmaster emeritus of the McCallie School. The principal address was by Dr. J. Allen Hynek, Ohio State University, on "The Twinkling of the Stars." The Jones Observatory was open to the public at the conclusion of the meeting.

On Saturday afternoon, at the observatory, the program included talks by amateurs. Other talks were by Dr. W. A. Calder, of Agnes Scott College, on uses of the Doppler effect in astronomy; by Dr. Carl K. Seyfert, of Vanderbilt University, on the new observatory at Vanderbilt; and by Prof. Mary Peters, of the University of Tennessee, on radio astronomy. A business session was followed by a discussion forum with Dr. Hynek as moderator and Drs. Calder, Peters, Seyfert, and Karel Hujer as experts.

The dinner celebrating the Barnard Astronomical Society's anniversary concluded the convention. There were 155 persons registered for the weekend, and over-all attendance was approximately 200, counting students and a few children.

New regional officers are C. H. Holton, chairman; Dr. Hujer, vice-chairman; P. O. Parker, treasurer; and W. H. Close, secretary. The 1954 convention will be held at Agnes Scott College, Decatur, Ga.

THIS MONTH'S MEETINGS

Dallas, Tex.: Texas Astronomical Society, 8 p.m., home of Mrs. W. L. Oliver, 1446 Glen St. July 20, field meeting.

Indianapolis, Ind.: Indiana Astronomical Society. July 5, telescope round-up, Butler University.

Kalamazoo, Mich.: Kalamazoo Amateur Astronomical Association, 8 p.m., home of Mr. and Mrs. Edgar Pashby, 420 Evelyn Ave. July 11, Phillip Steffey, "The Next Year in Astronomy"; George Royce, "Mysteries of the Moon"; Marlin Rughe, "Carolina Craters."

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

Schedule: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

Schedule: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

Schedule: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Public Library Building, Charleston, W. Va.

Schedule: Saturday, 11:15 a.m. Special showings on request. Admission free. Spitz projector. Director, Louise L. Morlang.

CHEROKEE, IA.: *Sanford Museum Planetarium.* Sanford Museum, 117 E. Willow St., Cherokee, Ia.

Schedule: Monday, 8 p.m. (except August). Admission free. Spitz projector. Director, W. D. Frankforter.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

Schedule: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:00 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.

Schedule: Saturday, 3:00 p.m.; Sunday, 3:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

Schedule: Wednesday, Thursday, and Friday at 8:30 p.m.; Saturday and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., 42-1858.

Schedule: Sunday, 2:45, 3:30, 4:15. Spitz projector. Supervising lecturer, James C. Foster.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

Schedule: Saturday, 2 and 3 p.m.; Sunday, 2:15 and 3:15 p.m.; Wednesday, 8 p.m. Spitz projector. In charge, Ray Stein.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

Schedule: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Chairman, Robert R. Coles.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

Schedule: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

Schedule: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.

Schedule: Saturday, Sunday, and Wednesday, 4:00 p.m.; Tuesday, Thursday, and Friday, 8:00 p.m.; Saturday show for children only, 10:30 a.m. Spitz projector. Director, Stanley H. Shirk.

PROVIDENCE, R. I.: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

Schedule: Wednesday at 3:30 p.m.; Saturday at 10:30 a.m., 2:30 and 3:30 p.m.; Sunday, 2 to 5 p.m. Admission free. Spitz projector. Acting director, Louis C. Ray.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

Schedule: Daily (except Monday and Tuesday) at 3:30, 7:30, and 9 p.m.; also at 2 p.m. on weekends and holidays. Academy projector. Manager, George W. Bunton.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

Schedule: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

Schedule: Sunday, 4:00 p.m. Admission free. Spitz projector. Director, Ernest T. Luhde.

NEWS NOTES

By Dorrit Hoffleit

GEGENSCHEIN STUDIES

In central Asia, seeing conditions are very good for observations of the faint counterglow or gegenschein that is seen at a point in the sky opposite the sun. Four important papers on the subject published by Russian astronomers in 1949 and 1950 have recently been translated by E. R. Hope, of Ottawa, Ontario, and are reviewed in *Nature* for March 28, 1953.

The counterglow is variable in shape, intensity, and in the spatial distribution of its luminescence. It has an emission spectrum thought to be induced by corpuscular radiation from the sun. Its parallax indicates a distance of only some 20 earth radii. These observations tend to support the theory that it is part of a gaseous tail extending from the earth's atmosphere.

In the late hours of the night, a "false zodiacal light" is seen between the descending gegenschein and the western horizon. In the preface to his translations, Mr. Hope offers the suggestion, assuming the gaseous tail theory, that the earth's radiation may assist the radiation pressure of sunlight on the evening side alone, counteracting it on the morning side. The gaseous stream may thus tend to be driven off only on the evening side, and the "sleeve" of the counterglow may be incomplete on its eastern side.

SOLAR ECLIPSE RESULTS

At the recent meetings of the American Geophysical Union in Washington, T. J. Kukkamäki, of the Finnish Geodetic Institute, Helsinki, and the Mapping and Charting Research Laboratory, Ohio State University, reported on geodetic results obtained from the total eclipse of the sun in 1947. One Finnish expedition had been sent to the Gold Coast of Africa, the other to Brazil. They used specially constructed cameras with continuously moving film (instead of the jumping film ordinarily used in movie cameras). The evaluation of the films gave the distance between the two observing stations to an accuracy of 94 meters. Most of this error is due to the current uncertainty in the profile of the moon's limb; when lunar profiles are better known, the error will be reduced to half its present value.

HANDICAPPED AMATEURS

In the *Journal* of the British Astronomical Association, we find an appeal for astronomical maps, books, and photographs for the Stannington Children's Sanatorium, Morpeth, Northumberland. To the extent that their physical handicaps will allow, boys at the sanatorium are trying to win their "Astronomer" or "Starman" badges in their local scout troop. The medical superintendent of the sanatorium, Dr. J. Arnold Stobbs, as scout district commissioner encourages their hobby, while Herbert W. Davidson, one of the house committee, has made himself responsible for their guidance and instruction. The *Journal* comments, "It is doubtful if any other hospital has among its patients a group of amateur astronomers."

Materials of all kinds should be sent to Mr. Davidson at 26 Staithes Lane, Morpeth, Northumberland, England. All gifts will be most gratefully received.

ARMIN OTTO LEUSCHNER

In April, Dr. A. O. Leuschner died at the age of 85. He was director of the Students' Observatory of the University of California at Berkeley from 1898 to 1938, and the observatory was renamed after him in 1951 (see *Sky and Telescope, 10,* 288, 1951).

Born in Detroit, Dr. Leuschner graduated from the Gymnasium at Cassel, Germany, in 1886, from the University of Michigan in 1888, and received his Ph.D. in Berlin in 1897. Between 1900 and 1938 he was the recipient of several honorary doctoral degrees. He had been associated with the University of California, first as mathematics instructor, then as astronomer, since 1890. Primarily a teacher, Dr. Leuschner was pre-eminent in this country in improving methods for the determination of the orbits of comets and planets and for his work on the perturbations of asteroids.

ICARUS AND RELATIVITY

The general law of relativity predicts that the perihelion points on the orbits of planetary bodies should advance in the course of time, at a rate that amounts to 43 seconds of arc per century in the case of Mercury. This planet has long been the sole test for this prediction, but the discovery of the asteroid Icarus, by W. Baade in 1949, provides another test, according to J. J. Gilvarry, of the Rand Corporation, in a note to the *Physical Review,* March 1, 1953.

The perihelion of Icarus falls within the orbit of Mercury, and the minor planet is subject to a large relativity effect; its perihelion advance is computed to be about 10 seconds per century. That of Venus is 8.6 seconds, but the possible precision of measurement of the perihelion motion for Icarus is more than 400 times as great as for Venus, and nearly five times as great as for Mercury. Thus, although it may take decades for sufficient observational data to accumulate, Icarus is apparently the most favorable body for checking the precessional formula of general relativity.

ROGER WILLIAMS PLANETARIUM

The dedication of the new planetarium in Providence, R. I., took place on May 17th, and public showings started on June 1st. The planetarium is in a 24-foot plastic dome, seating 90 persons, in the Roger Williams Park Museum. In the week following the dedication ceremonies, a series of private evening showings was given for all those who had donated five dollars or more to the planetarium fund (see the April issue, page 160). Armand N. Spitz, inventor of the Spitz projector, gave one of the special lectures; others were given by lecturers from the Boston Museum of Science, the University of Rhode Island, the Stamford Museum, and the naval station at New London.

Demonstrations with the Roger Williams projector will change every two weeks (see Planetarium Notes for lecture times). The summer lectures are: July 1-14, The Southern Sky; July 15-August 3, Time and Place; August 4-18, Star Myths and Legends; August 19-September 1, The Land of the Midnight Sun; September 2-13, Autumn Skies.

IN THE CURRENT JOURNALS

THE STUDY OF SHADOW-CASTING METEORS, by C. C. Wylie, **Leaflet** No. 288, Astronomical Society of the Pacific, April, 1953. "People with the best intentions seem perfectly sure of all sorts of violations of the laws of nature. Credible people sometimes report incredible things."

THE EARTH'S ELECTRICITY, by James E. McDonald, **Scientific American,** April, 1953. "The earth is charged with respect to the atmosphere, and the atmosphere is sufficiently ionized to be a conductor. How, then, is the earth capable of maintaining its charge?"

LUMINOUS AND DARK FORMATIONS OF INTERGALACTIC MATTER, by F. Zwicky, **Physics Today,** April, 1953. "Most of these formations are of very low surface brightness, and have therefore not been noticed in the past. They were first brought to light with the help of the large, powerful Schmidt telescope using fast emulsions and, last but not least, by careful work."

CELESTIAL SPEEDS, by C. H. Cleminshaw, **Griffith Observer,** April, 1953. "Among the most breath-taking discoveries are the extremely high speeds with which the objects in the universe are moving."

TWO MIRRORS: THE STORY OF THE INVENTION OF THE SEXTANT, by Grenville D. Zerfass, **The Ensign,** May, 1953 (courtesy of **Navigation**). "In its own inexorable way the restless sea decides what it will permit man to do and what it will deny him. The instruments that navigators would use it examines and approves or rejects."

THE DISTANCE SCALE OF THE UNIVERSE -- II

By Otto Struve, *Leuschner Observatory University of California*

BETWEEN the time of the first determination of the zero point of the period-luminosity curve and the present, numerous attempts have been made to revise the original value. B. P. Gerasimovich, J. H. Oort, K. Lundmark, Priscilla F. Bok, H. Mineur, J. Schilt, and others have indicated various corrections to Shapley's zero-point determination. The range covered by these corrections was about 1.5 magnitudes, indicating among other things how difficult it is to derive the zero point accurately.

Shapley himself, however, estimated at one time that the error of the adopted zero point would not exceed a quarter of a magnitude. This prediction, made in 1930, was seemingly confirmed by R. E. Wilson in 1939, when he re-derived the zero point on the basis of a large mass of new data on the radial velocities and proper motions of the Milky Way Cepheids. His extensive computations "indicated corrections to the photographic period-luminosity curve amounting to 0.00 ±0.2 for the short-period variables, and −0.14 ±0.2 for those of longer period, if we correct for galactic absorption of 0.85 magnitude per kiloparsec."

Despite these earlier results, it is now probable from the work of Baade and his collaborators that the zero point of the classical Cepheids was in error by 1.5 magnitudes, while that of the cluster-type Cepheids (RR Lyrae variables) was about correct.* In Shapley's period-luminosity diagram, these two groups of variables form one continuous curve, the cluster-type variables with periods of one-half day being about two magnitudes fainter, intrinsically, than the classical Cepheids with 10-day periods. The latter, on direct photographs of M31 with the 100-inch Mount Wilson telescope, have apparent magnitudes of 20. The former were too faint to be observed with the 100-inch, but were predicted to have apparent magnitudes of 22. They should therefore have been easily accessible to the 200-inch Hale reflector on Palomar Mountain.

Yet, Baade stated at Rome, "The very first exposures on M31, taken at the 200-inch telescope, showed at once that something was wrong. Tests had shown that we reach with this instrument, using the f/3.7 correcting lens, stars of photographic magnitude 22.4 in an exposure of 30 minutes. Hence we should just reach in such an exposure the cluster-type variables in M31, at least in their maximum phases. Actually we reach only the brightest stars of Population II in M31 with such an exposure. Since, according to the latest color-magnitude diagrams of globular clusters, the brightest stars of Population II are photographically about 1.5 magnitudes brighter than the cluster-type variables, we must conclude that the latter are to be found in M31 at photographic magnitude 23.9±, and not at 22.4, as predicted on the basis of our present zero points."

Thus the Andromeda galaxy must be much farther away than we had heretofore considered it to be, for not only are we unable to observe its cluster-type variables at the limit of the 200-inch telescope, but at that limit we only begin to see the brightest stars of Population II. Dr. Baade pointed out that there

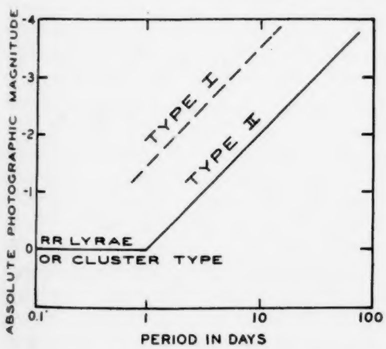
The spiral nebula Messier 33, in Triangulum, has long been considered to be at about the same distance as Messier 31, nearby in Andromeda. Therefore, the new scale places this open-type galaxy at a distance of about 1½ million light-years. Mount Wilson and Palomar Observatories photograph.

*For a discussion of the several kinds of pulsating variables, see Dr. Struve's article, "Variable Stars and Stellar Evolution," *Sky and Telescope*, April and May, 1950.—ED.

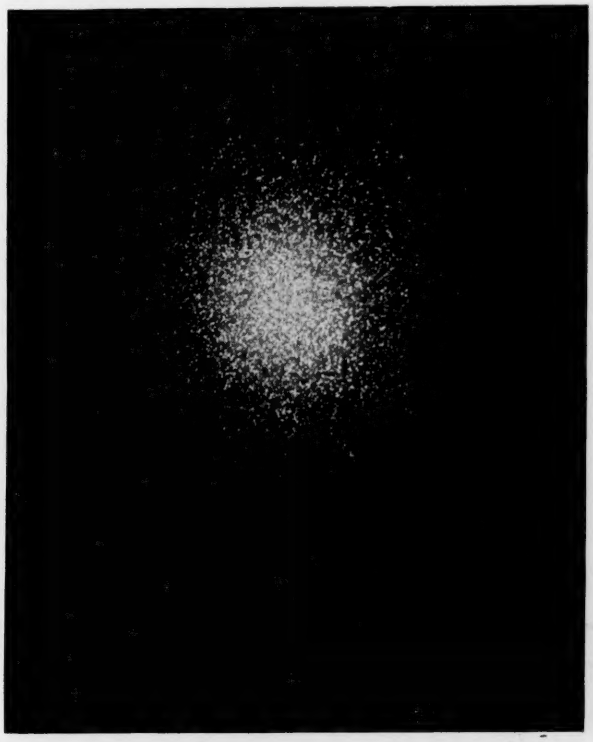
is convincing proof that these brightest stars (red long-period variables) are properly identified because they emerge above the plate limit just when the globular clusters of the Andromeda system begin to be resolved into stars. (This resolution is another achievement of the 200-inch instrument.)

Obviously, this result does not of itself tell us whether the period-luminosity curve of the classical Cepheids or that of the cluster-type stars is in error by 1½ magnitudes. This point was settled by Baade with the help of Sandage's color-luminosity diagram of the globular cluster M3 (see *Sky and Telescope*, January, 1953, page 63), in which the dwarf branch was recorded. If we compare this dwarf branch with Harold Johnson's dwarf branch of the nearby stars (for which distances are very well determined), we find that Sandage's and Johnson's diagrams can be brought into coincidence when the cluster-type variables in M3 are given an absolute magnitude of 0.0 — in exact agreement with the earlier determinations. The error of 1.5 magnitudes, corresponding to an error in the resulting distances of a factor of two, in the sense that they must all be increased by this number, is thus attributable to the classical Cepheids. The curve representing their intrinsic brightness-period relation should apparently be raised 1.5 magnitudes above that for other long-period pulsating variables, such as the W Virginis stars.

Perhaps the best way to make the distinction between the Cepheids is to follow Baade in separating them into type I and type II, corresponding to his general division of all stellar objects into Populations I and II. The classical or type-I Cepheids are those for which the period-luminosity curve must be raised—that is, they are intrinsically 1½ magnitudes brighter than type-II Cepheids of corresponding periods (including W Virginis stars). The cluster-type or RR Lyrae variables are of very short period; their luminosities remain unchanged, and they still form part of the original period-luminosity curve along which the type-II Cepheids fall, as shown in the accompanying diagram.



There are now two period-luminosity curves instead of the single one formerly employed in estimating the distances of remote Cepheids. The classical or type-I Cepheids are about 1½ magnitudes brighter than the type-II Cepheids. The upper curve can now be drawn from Baade's new observations of neighboring galaxies; the lower curve is still identified with variables in globular clusters.



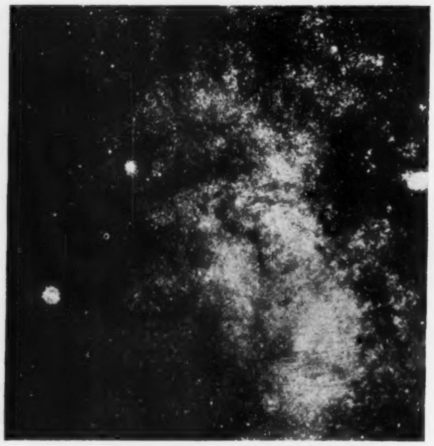
The distances to the globular clusters associated with our Milky Way galaxy are not changed by the new scale. This is because the variables they contain are all of type II (either RR Lyrae or longer period Cepheids) and fit the original period-luminosity relation. This is Omega Centauri, one of many globulars used by Shapley in confirming the original curve for type-II variables. It is at a distance of 20,000 light-years. Harvard Observatory photo.

The type-I Cepheids, in our Milky Way and in the distant galaxies, are therefore twice as far away as had been previously assumed. But the distances of the globular clusters, and of the Milky Way starclouds in Sagittarius, which have been estimated with the help of the cluster-type variables, remain unaffected. Our galaxy's size remains the same as before, but the Andromeda galaxy is now placed at a distance of 1,500,000 light-years (distance modulus 23.9 magnitudes). Hence, it is also twice as large in diameter as was previously thought likely. It is, in fact, a little larger than our Milky Way system.

Baade's work has been confirmed by the independent results of A. D. Thackeray with the 74-inch Radcliffe Observatory reflector in South Africa. At the Rome meeting he announced that the first cluster-type variables found in the Small Magellanic Cloud have magnitudes of the order of 19.0. The old period-luminosity relation had predicted a magnitude of 17.4. Again the classical Cepheids, with periods of between one and 40 days, are at fault. The Magellanic Clouds are twice as distant as we had thought previously.

Also in line with Baade's results are some recent observations of colors and magnitudes of star clusters in the two Magellanic Clouds, by S. C. B. Gascoigne and G. E. Kron, on the basis of work at the Mt. Stromlo Observatory in Australia. Some of their clusters are probably globular in kind — yet they have found these clusters about 1.5 magnitudes fainter, intrinsically, than the globular clusters of the Milky Way. Since the globular clusters are probably all rather similar to one another, the suspicion arose, as in the Mount Wilson work, that the distances of the Magellanic Clouds had been underestimated. Work of a similar nature on the Magellanic Clouds has been recently carried on at Harvard's southern station, and Shapley sets the revised distance to the clouds at 150,000 light-years, making their respective diameters 30,000 and 20,000 light-years. This result was announced by Shapley at the December, 1952, meeting of the American Astronomical Society at Amherst. Thus, it would appear that there is complete unanimity among the active workers in this field that the new zero point of the period-luminosity relation has now been fairly accurately determined.

The new distance scale helps to reconcile a number of contradictions that had resulted from the previous scale. The observable part of the universe is now so large that a time interval of 3.6×10^9 years is required to account for the expansional velocities of the galaxies — that is, the expansion began 3,600 million years ago. This new time-scale agrees with the radioactive determination



Within the Milky Way, as in this view toward the galactic center in Sagittarius, the distances are unchanged.

of the age of the earth and with the evolutionary time-scale of the stars.

The maximum range of the 200-inch telescope is two billion (2×10^9) light-years, and that of the 100-inch instrument is double what we had thought it to be all along; it now sees a billion light-years into space.

Still another consequence of Baade's work was commented upon at Rome by J. Dufay. Formerly, the diffuse gaseous emission nebulae in the Milky Way had appeared to be about twice as large as in the Magellanic Clouds and in the outer galaxy NGC 6822. The new distance scale makes these sizes practically the same. The same improvement in relative sizes results for the stellar associations of blue giant stars that we can identify both in our own and in nearby galaxies — these now seem to follow a standard pattern for size.

The new luminosities of the classical Cepheids require that they be physically larger by a factor of two, and thus less dense by a factor of eight than had been assumed previously. This agrees much better with the theory of stellar pulsations described in our article this March.

The question still remains unanswered: Why was the zero point of the classical Cepheids in error by as much as 1.5 magnitudes? In Shapley's early work it was not yet realized that the cluster-type variables belong to Population II (old stars), while the classical Cepheids are nearly all members of Population I (young stars). Hence, in the earlier discussions there was a tendency to force the period-luminosity relation to form a continuous curve from the shortest periods of two hours to the longest periods of 40 or 50 days.

The faint irregular galaxy NGC 6822, in Sagittarius, is one of the members of the local system. The distance to this object must now be doubled, to over a million light-years. Mount Wilson Observatory photograph.

We now know that the constitutions of the stars of Populations I and II are not the same and that the zero points for the two groups of variables are independent quantities. The existence of a discontinuity in the period-luminosity relations of the cluster-type variables and of the classical Cepheids was already recognized by B. V. Kukarkin in 1949, but after a rediscussion of the data used by Wilson in 1939 he still found a difference of only two magnitudes between the 10-day Cepheids and the half-day cluster-type variables. This was the value that had led to the wrong prediction in the case of the Andromeda galaxy.

It is improbable that errors of measurement in the proper motions or in the radial velocities could have caused so large an error in the mean distances of the Milky Way Cepheids. It is true, however, that because these stars are all relatively distant their proper motions are small and therefore more difficult to measure satisfactorily against the still smaller motions of the background comparison stars on which the measurements of proper motion must depend. The statistical method of determining the Cepheid distances, described last month, must be searched further for possible anomalies in Cepheid behavior that make the method inapplicable to these stars.

For instance, what is the true radial motion of a Cepheid? These stars have fairly large systematic velocities away from the sun, as was found, for example, by O. A. Melnikov in his study of the so-called K effect. There is also some question of whether or not the mean radial velocity of a pulsating gas bubble really represents the motion of its center of gravity. If all Cepheid velocity curves should turn out to be discontinuous (see Sanford's RR-Lyrae observations discussed in March), we would have to argue long and hard as to what we should regard as the star's true velocity.

Another question is whether or not the Cepheids represent a peculiar system of stars which possess unusual dynamical properties with respect to the sun and its more normal neighbors. Perhaps they form a stream whose motion with respect to the sun is unsymmetrical. The statistical determination of the zero point makes the assumption that there is no such peculiarity of motion. It is also possible that the recent discovery of spiral structure in the galaxy will result in a modification of the earlier statistical derivations of the zero point. The Cepheid variables of our galaxy may belong to several different arms in the vicinity of the sun, and for all we know these arms may not have the same properties of galactic rotation.

The strongly nucleated spiral NGC 5236, M83, which now is placed at about six million light-years. Photograph with the 60-inch telescope of the Boyden station, Harvard Observatory.

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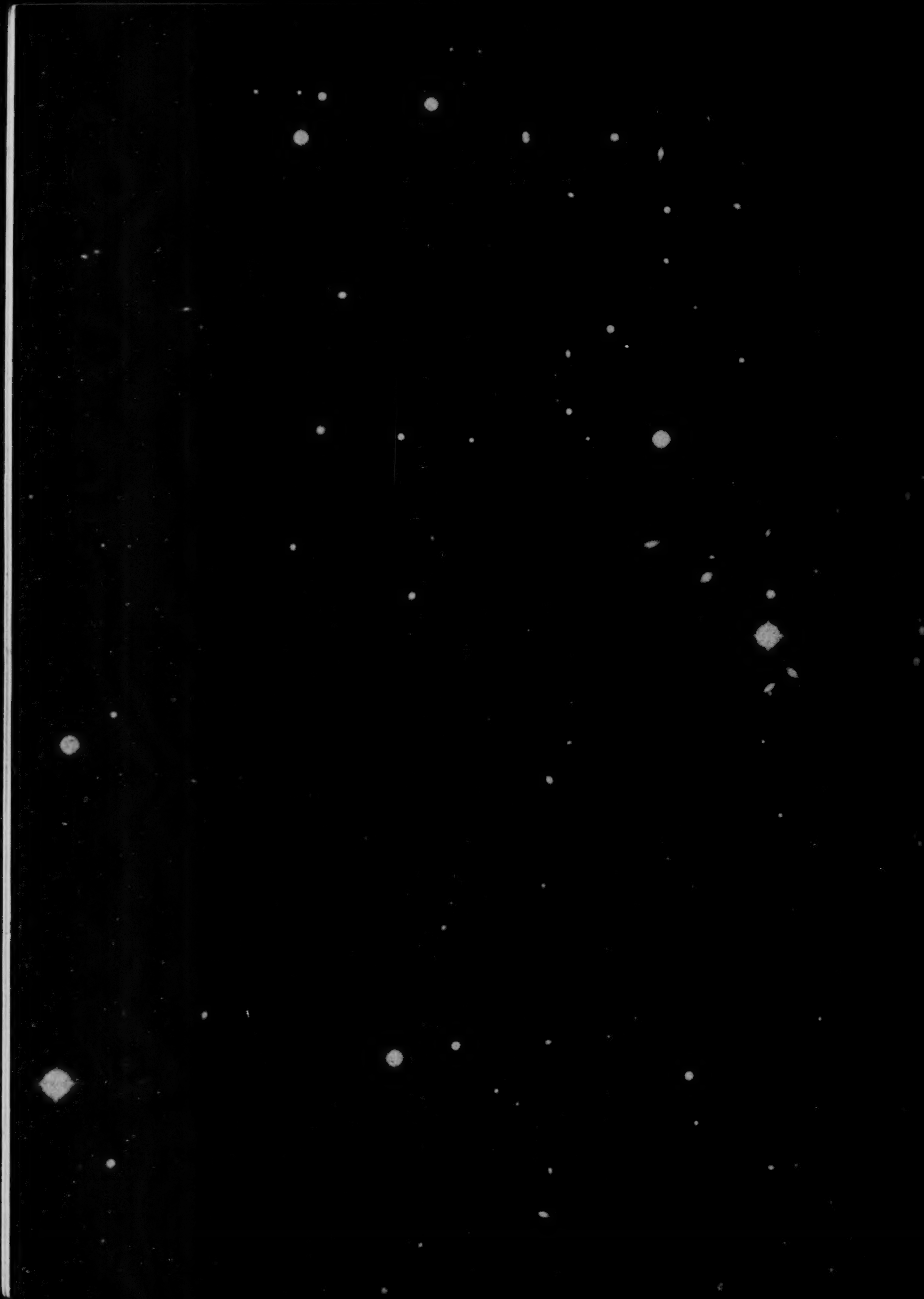

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BOOKS AND THE SKY

STATISTICAL ASTRONOMY

Robert J. Trumpler and Harold F. Weaver. University of California Press, Berkeley, 1953. 644 pages. $7.50.

THE LONG-AWAITED TEXTBOOK by Trumpler and Weaver has appeared in print. It is based for the greater part on the course in statistical astronomy which Dr. Trumpler has taught for the past 20 years at the University of California in Berkeley and which, since Dr. Trumpler's retirement, has been given by Dr. Weaver. In this text we find the traditional methods of the past treated along with the newly developed modern techniques of statistical analysis.

The Leuschner Observatory at Berkeley seems an almost ideal place for the writing of a text on statistical astronomy. The authors have had the advantage of writing in the shadow and within easy reach of California's great observatories, Lick and Mount Wilson and Palomar. At the same time, they did not have to go far to refresh their minds or be kept up to date on statistical theory, for the Statistical Laboratory of the University of California is located on the same campus as the Leuschner Observatory. The text is adequate proof that the authors have taken full advantage of their unique environment.

Someone like myself, who for many years has taught graduate courses in galactic structure and in stellar motions and dynamics, has naturally developed certain preferences with regard to the treatment of the material that do not coincide with those of his colleagues, and he will almost surely have misgivings about the treatment in parts of any text in the field. Before I present my praise tempered with criticism, however, I should go on record to express to the authors my admiration for the thoroughness with which they have executed their difficult task and with it my appreciation for what they have done toward making the techniques of analysis employed in Milky Way research more generally known and available.

The Trumpler-Weaver text is divided into six parts, some of which are almost like complete texts in themselves. This applies especially to Part I, "Elements of Statistical Theory," 230 pages in length. Here the student (and the instructor!) will find a complete and self-contained introduction to modern statistical analysis. Chapters 1.4 and 1.5 deal with the integral equations of statistics and with the corrections of frequency distribution for observational (accidental) errors, and these will be of special interest to the astronomer. I found Chapter 1.8 on the testing of hypotheses (by Dr. Elizabeth L. Scott) especially worth reading.

I was somewhat surprised at certain omissions in this otherwise very comprehensive part. Nowhere did I find specific mention of most phases of the important topic of observational selection. For example, I did not find treated the basic statistical problem of multiple discovery and its significance for the derivation of the probable true frequencies of, say, variable stars within specified ranges of type, period, and apparent magnitude. I had also hoped this first part would contain a treatment of tests for deviation from random distribution, tests which are proving so important in studies of the surface and space distributions of faint galaxies.

Part II discusses the "Statistical Description of the Galactic System." This part is disappointingly brief (29 pages). I presume the authors are of the opinion that the budding statistical astronomer should shop elsewhere for his observational background and for knowledge about the presently available data of observation. This seems hardly the correct approach for a field of applied statistics in which the reliability of one's conclusions is determined, in the end, often more by the quality and character of one's basic observational material than by the precise technique of analysis. My personal preference would have been for a ratio 2:1 rather than 8:1 for Parts I and II. It is a pity to find in Part II that spectral classification is disposed of in three brief paragraphs, photoelectric colors are mentioned once, and photoelectric magnitude determinations are referred to only in a footnote. The student is not given an awareness of systematic errors and their ever-present danger for statistical analyses. The brevity of Part II is to be deplored all the more since the authors are as qualified as any pair of astronomers to speak with authority on these matters.

Parts III and IV deal with stellar motions for the vicinity of the sun, and problems of the distribution of luminosities and spectral types. The treatment is thorough, and throughout these and the subsequent parts an effort is made to acquaint the future computer with the sort of problems that he will encounter in his day-to-day work. It is somewhat regrettable that in the derivation of luminosity functions the emphasis is so greatly on treatment of separate components of proper motion rather than on total proper motions; the latter generally yield results of greater weight since the correlation between components is automatically considered in the analysis and since the effects of systematic errors are minimized when total proper motions are used.

Part V, on the space distribution of the stars, contains some excellent hints for analysis of space densities in the Milky Way system, with full consideration of effects introduced by interstellar absorption and with an example very completely worked out. The treatment of dark nebulae and how to find their distances and absorptions is clean and comprehensive. In the reading of this part, however, I felt very strongly the need of more direct contact with observation. A student might well work through this section without having a clear notion of what sort of phenomena are really observed along the band of the Milky Way, of what a dark nebula looks like, and of how irregular is the surface distribution of the stars almost anywhere along the Milky Way. It would seem that the student should first be given a bit of a cosmic view of the

problem that concerns him. He should be introduced to the realities of spiral structure in galaxies outside our own before delving into the gorgeous complexities that we encounter in our own system. (I note that the word "spiral" is not listed in the index!)

Part VI, on "Galactic Rotation," is a good and useful group of chapters, but it does not seem firmly related to the overall subject matter of the book. When I began reading it for the first time, I had hoped that the authors might have worked toward a grandiose windup, stressing models of our galaxy, instead of providing a transition toward galactic dynamics, which need not find a place in the present text.

Considering the book as a whole, I am wondering if the title **Statistical Astronomy** does not promise more than is delivered in the end. To my mind, statistics of meteors, asteroids, and comets, of solar phenomena, of variable stars, of the distribution of stars in galactic and globular clusters, and of the distribution of galaxies over the sky and in space, are all a part of statistical astronomy. The Trumpler-Weaver text specifically limits itself, however, to the narrower problems of spectra, luminosities, and motions in the nearer parts of our own Milky Way system, but no one will deny that it gives full and adequate coverage to this phase of statistical astronomy.

The authors deserve the thanks of their colleagues and of students, present and future, for the care with which they have assembled and systematized statistical treatments scattered far and wide in the literature. Several of the techniques of analysis that are described are original with the authors. No one who thinks seriously of dealing with problems of galactic structure can henceforth afford to pass by the Trumpler-Weaver volume. It is a book that should appeal to the amateur astronomer or statistician versed in mathematics; the professional astronomer and his graduate students must take time to study it with care.

The book has been beautifully produced and printed. In spite of its bulk, it handles easily. The diagrams are excellent, and they are as clearly drawn as any I have seen.

BART J. BOK
Harvard College Observatory

NEW BOOKS RECEIVED

OCCASIONAL NOTES, Vol. 2, No. 14, December, 1952. *Royal Astronomical Society*, Burlington House, London W. 1, England. 40 pages. 5s.

This series of articles, in pamphlet form, includes "The Rocket and the Future of Astronomy," Arthur C. Clarke; "The Blue Sun of 1950 September," R. Wilson; "The Story of the Greenwich Transit Circle," W. M. Witchell; "A History of Extreme Errors in Fundamental Declinations," F. Schmeidler. Copies of the pamphlet may be ordered directly from the Royal Astronomical Society.

ASTROPHYSICS — The Atmospheres of the Sun and Stars, *Lawrence H. Aller*, 1953, *Ronald Press*. 412 pages. $12.00.

A text for students and research workers, by an associate professor of astronomy at the University of Michigan. The background of physics necessary for a study of stellar atmospheres and other branches of astrophysics is given, and these principles are applied to the radiation of the sun and stars, to their continuous and dark-line spectra, to solar phenomena, and to solar-terrestrial relationships.

GALILEO: First Observer of Marvellous Things, *Elma Ehrlich Levinger*, 1952, *Julian Messner*. 180 pages. $2.75.

A popular account of Galileo's life and work, with considerable emphasis on his contributions to astronomy.

PLANET X, *Mildred S. Kiefer*, 1953, *Julian Messner*. 62 pages. $1.60.

A story for young children, with a background about Lowell Observatory, the search for Pluto, and the problem of life on Mars.

THE END OF THE WORLD, *Kenneth Heuer*, 1953, *Rinehart*. 220 pages. $3.00.

This popular account opens with a chapter on some of the various legends and prophecies about the world's end. Then different ways are explored in which the world may actually end, such as collision, the sun becoming a nova or ceasing to shine, and atomic war.

DE MOTIBUS CELORUM, *Al-Bitruji*, Francis J. Carmody, editor, 1952, *University of California Press*, Berkeley. 180 pages. $2.75, paper bound.

The text of the 13th-century Latin translation by Michael Scot of al-Bitruji's 12th-century Arabic work on astronomy is given in this book, preceded by 70 pages of analysis, discussion, and annotation by Dr. Carmody. The present volume, the editor says, "is an attempt to show exactly what al-Bitruji thought and something of the relationship of his thought to astronomy in Western Europe during the middle ages. . . ." The book should be of particular interest to astronomers interested in the history of their science.

AMATEUR WEATHERMAN'S ALMANAC, 1953, *David M. Ludlum*, editor, 1953, *Weatherwise*, Franklin Institute, Philadelphia 3, Pa. 84 pages. $1.00, paper bound.

This is the second annual appearance of a handbook for the weather observer. There are illustrated articles discussing 1952's weather, and tables of the past year's weather statistics. Hints on forecasting, and blank pages for the observer's weather log are included.

MAN AND HIS PHYSICAL UNIVERSE, *Richard Wistar*, 1953, *Wiley*. 488 pages. $4.75.

This integrated course in physical science, at the college level, covers units on photography, the solar system and beyond, the earth, the weather, electricity and magnetism, and atomic structure. A summary and a set of questions and exercises conclude each chapter. The book is aimed for students who will probably not be scientists, but "will be citizens in a world where scientific problems are constantly confronting the general public." The author is associate professor of chemistry at Mills College.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

NOTES ON BASIC OPTICS — II

B. Image Characteristics

1. **Positive Lenses.** Now we consider what happens to the image when the object is moved to different locations. We can, of course, make the construction described in May (Fig. 3) for any given object position, but we can more conveniently study the effect of object movement by looking at Equation 1, which may be rewritten thus:

$$\frac{1}{\mathbf{d'}} = \frac{1}{\mathbf{f}} + \frac{1}{\mathbf{d}}. \qquad (1a)$$

Our procedure will be to see what happens to **d'** when we vary **d**.

Suppose at first the object is very far away to the left of the lens. Then **1/d** is nearly zero, and **d'** equals **f** for all practical purposes. This is the case corresponding to an optically infinitely distant object, from which parallel rays of light are received—the light is "collimated." This is the significance of the number **f**; it is the image distance for collimated light—the infinity focus of the lens, and is illustrated in Fig. 1C.

Now bring the object closer to the lens. The value of **d** is still large, and it is negative, since it is to the left of the lens; hence the term **1/d** is a small negative number, and **1/d'** is slightly smaller than **1/f,** whence **d'** is slightly larger than **f** and positive. It is evident that as the object is moved toward the lens from the left, the image, starting at a distance **f** to the right of the lens, moves in the same direction, that is, to the right.

As we continue to bring the image in from the left, **d** grows smaller, but remains negative, **1/d** grows larger, and **1/d'** grows smaller; hence **d'** grows larger and remains positive, indicating an image to the right of the lens that moves farther and farther away as the object comes closer. The limit is evidently reached when **d** equals **—f,** for in this case **1/d'** is zero, and **d'** equals infinity; that is, when the object is placed at a distance **f** to the left of the lens the image is at an infinite distance to the right. This is to be expected, and it shows us that the lens works equally well turned either way. This is another way of stating a general law of optics: If the direction of a light ray is reversed, its path will not change.

At this point, we take note of one case of special significance that we shall discuss later. When object and image are equidistant from the lens, **d'** equals **—d,** and **d** equals 2f.

Now move the object even closer to the lens than the distance **f**. In this case,

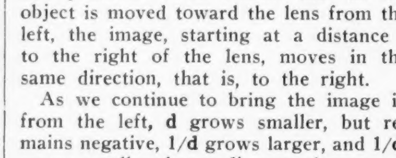


Fig. 5. The simple magnifier condition.

1/d is still negative, but larger than **1/f,** and **d'** becomes negative. This condition is that prevailing in a simple magnifier, and is illustrated in Fig. 5. The image now lies on the same side of the lens as the object, and is **virtual,** in accordance with our previous definition. When **d** is only slightly smaller than **f, d'** is a large negative number, and the virtual image is formed at a great distance. Theoretically, a simple magnifier (or an eyepiece) should be used with **d** equal to **—f,** in which case the image is at infinity. Most people, however, find it more comfortable to adjust an eyepiece until **d'** is about one or two meters, which means that the object is placed slightly inside the focus.

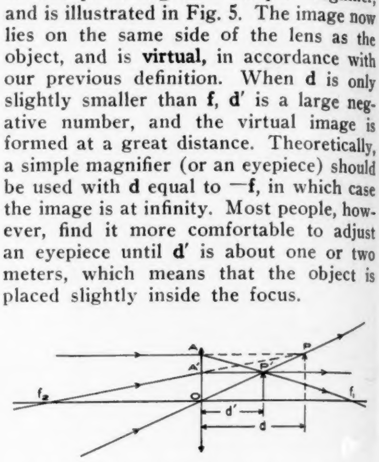


Fig. 6. The "intercepted" object case.

As we continue moving the object toward the lens, **d'** becomes smaller and smaller but remains negative, until the point at which **d** is zero, whence **1/d** is infinite, **1/d'** is infinite, and **d'** is zero also. Thus, object and image coincide when both are at the lens itself. This is the basis of the fundamental principle, of which we shall make use later, that we may place a lens directly in a focal plane without any first-order effect on the image.

But we have not finished. It is possible to have the object lie on the right of the lens, with the light incident from the left. This corresponds to the case where a lens is placed in the converging beam from another lens. In this case, **d** is positive and **1/d** is added to **1/f; 1/d'** is greater than **1/f,** and therefore **d'** is smaller than **f** (Fig. 6). In particular, when **d** equals **f, d'** equals 1/2f. When **d** finally becomes infinite, **d'** equals **f,** and we are back where we started. For all cases where **d** is positive, **d'** is positive and less than **f,** which means that the image lies to the right of the lens and closer than **f.**

2. **Negative Lenses.** If the same operations are performed with a negative lens, **f** must always be negative. When **d** is infinite, **d'** equals **f,** as in the case of the positive lens, but now **d'** is negative, and the image is on the left of the lens and is virtual. This was illustrated in Fig. 1D.

If the object is brought in from the left, **d** becomes a negative number, growing smaller, hence **1/d** becomes greater, **1/d'** becomes greater and negative; thus **d'** is negative and grows smaller. This means that the virtual image, starting at **f** to the left of the lens, moves closer to the lens and finally coincides with the object when both are at the lens itself, exactly as was the case with the positive lens.

Now continue to move the object to the right, corresponding to the case of a neg-

ative lens placed in the convergent beam of another lens. Then **d** becomes positive and, at first, small, so that 1/**d** is large and 1/**d'** is positive and large; hence, **d'** is positive and small and the image moves to the right and becomes real (Fig. 7). Finally, when **d** equals −**f**, 1/**d'** is zero, and the image has moved out to infinity, which is the case with which we started.

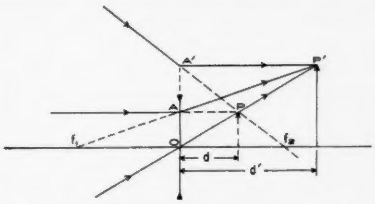


Fig. 7. **Negative lens "interception."**

3. **Magnification and Inversion.** One of the construction lines for image formation by any lens is the line **POP'**, from an off-axis object point through the center of the lens to the corresponding image point. Look at it carefully for a while, as in Fig. 3 and Figs. 5, 6, and 7, and you will note two facts. First, the relative sizes of object and image are the same as their relative distances from the lens. Second, whenever the image is on the same side of the lens as the object the image is "right side up," while when object and image are on opposite sides of the lens the image is "upside down." The optical terms for these two situations are **erect** and **inverted,** respectively.

The change in size between object and image in accordance with their respective distances from the lens is one kind of magnification — **linear magnification.** We express it as

$$\mathbf{d'/d = M.} \qquad (2)$$

The values of **d'** and **d** come from Equation 1. Note that if the object and image are on the same side of the lens, **d'** and **d** have the same sign and **M** is positive; if object and image are on opposite sides of the lens, **d'** and **d** are of opposite sign and **M** is negative. Thus, Equation 2 tells us not only the image size, but whether it is erect or inverted.

What is drawn in the plane of the paper in our diagrams occurs also in a plane at right angles to the paper, so that when a lens inverts an image it does so both

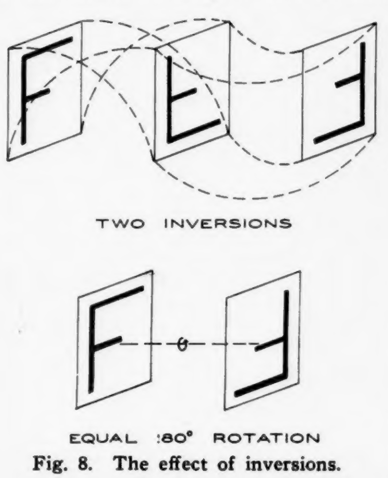


Fig. 8. **The effect of inversions.**

from right to left and from top to bottom. Inverting in two planes like this is the same as rotating the image 180 degrees around the optical axis (Fig. 8). Any two perpendicular inversions will produce the same effect, as there is nothing unique in the planes indicated by up and down, right and left.

To recapitulate this month's discussion, if we have a lens and an object at a known distance from it, we can find the location of the image, its size, and whether it is erect or inverted by just knowing one number: the focal length of the lens. And this information is derived from two very simple equations.

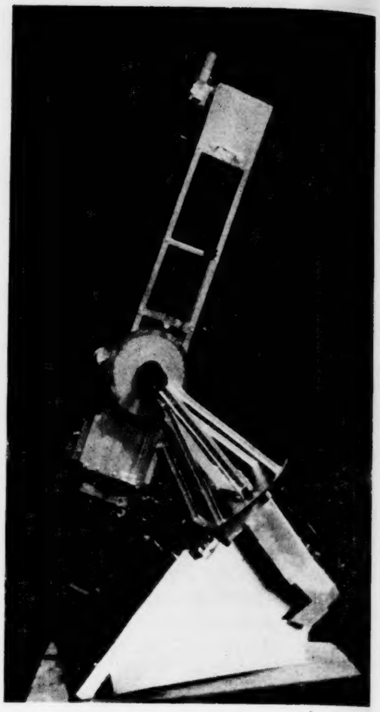
(To be continued)

AN ENGLISH REFLECTOR

THE PHOTOGRAPHS show my 8-inch Newtonian reflector. The tube is of steel angle and the mirror, which has an aluminum on chromium coating, is in a cell made from an old truck wheel. The cell has a three-point support to the base of the tube, and is pulled up against spring tension by two rods which pass up outside of the tube and end in butterfly nuts near the eyepiece. Thus, it is possible to collimate the mirror without moving the eye from the eyepiece draw tube.

The drum on the top of the tube above the declination circle contains a 6-volt battery supplying current to the lamp illuminating the crosswires in the finder.

The mounting originally started as a plain fork made from U-section mild steel welded to a 2" steel rod, turning in two ball bearings. But like many beginners, I had made the mistake of confusing strength with mass, and the telescope whipped up and down with every movement. To overcome this defect, a disk was cut out of a piece of 1/2" steel plate and turned up to a true circle with the edges beveled. A 2" hole was bored in the center and the polar axis was dropped through until the base of the fork rested across the face of the steel disk.

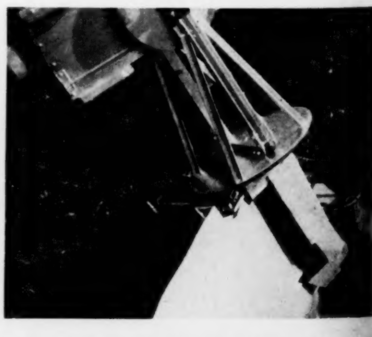


The Buie reflector, of which a mounting closeup is shown below.

After the fork was welded to the disk, supporting arms were welded from the perimeter of the disk to the ends of the fork arms; this resulted in a very rigid structure which does not show any signs of vibration.

As all this made a considerable increase in the weight that had to be carried by the 2" ball bearings of the polar axis, two small steel wheels shaped to take the beveled edge of the disk were made. These were fixed to the front of the steel angle base, where they can be adjusted in height until they just take the weight off the bearings.

At the moment, the telescope has no drive or slow-motion attachments, but I may fit these later. In operation, however, unless the tube is pointing toward the pole, the whole instrument can be moved with a touch of the finger, and following a star presents no difficulties.

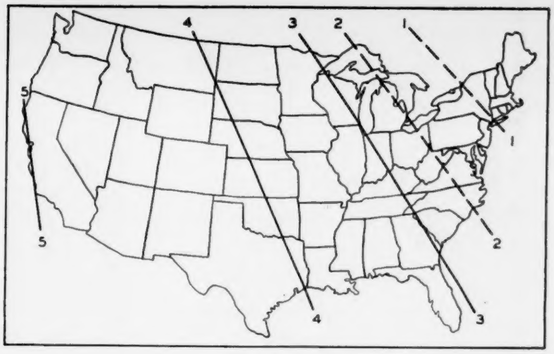


H. B. BUIE
"Altair," Epsom Rd.
Ashtead, Surrey, England

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

The Total Eclipse of the Moon on July 26th



The partial phases of the eclipse will be visible only west of line 3, and totality only west of line 4. On the West Coast, the moon will set just as it begins to emerge from total eclipse. Line positions computed by Paul W. Stevens.

MANY READERS may recall the beautiful total lunar eclipse of July 15-16, 1935, when the middle of the eclipse occurred very close to midnight in the Eastern standard time zone, with the moon at culmination near the 75th meridian of longitude. Furthermore, the passage of the moon through the earth's shadow was very nearly central.

Now that 18 years have elapsed, the next eclipse in the saros is about to occur. This one on July 26th will be similar to the eclipse of 1935, except for the characteristic lag of approximately 10⅓ days in the time of year and a shift of 120 degrees west in longitude. Accordingly, this will be a sunrise eclipse throughout much of the United States and will be entirely invisible in the northeastern part of the country. The maximum magnitude of the eclipse will be 1.869.

The accompanying map shows the zones of visibility of the various phases. Each line is the locus of points where the moon's lower limb will be on the horizon under one of the circumstances indicated below. Account has been taken of atmospheric refraction and of lunar parallax and semidiameter, but the dip of the horizon has been ignored. Lines for other magnitudes of the eclipse can be estimated by interpolation.

Line	UT (h m)	Circumstance	Magnitude
1	9 35.9	Moon enters penumbra	−0.99
2	10 09.5	Visible darkening of east limb	−0.40
3	10 32.5	Moon enters umbra	0.00
4	11 29.9	Totality begins	+1.00
5	13 11.4	Totality ends	+1.00
	14 08.8	Moon leaves umbra	0.00
	15 05.3	Moon leaves penumbra	−0.99

From stations in the zone between lines 2 and 3, it will be interesting to observe and photograph the penumbral phase. A systematic program should start at the time the moon enters the penumbra and continue until moonset. If sufficient observations are made from widely scattered locations, it will be of value to compare results and determine the effect of variation in brightness of morning twilight on the detection of the penumbral darkening.

Sunrise will coincide with moonset on a line where the magnitude at the horizon is approximately +0.50, halfway between lines 3 and 4. West of this line, it will be possible to see the sun and moon simultaneously for a brief period during the eclipse.

PAUL W. STEVENS
Rochester Academy of Science

LABORATORY ECLIPSE

While lunar eclipses are exquisite sights in amateur telescopes, it is difficult to get satisfactory photographs. After I had visually observed totality of the January eclipse with my 5½-inch refractor, the telescope was converted to a prime-focus camera, but it was impossible to get satisfactory rendering of the partially eclipsed moon because the bright and darkened parts were overexposed and underexposed, respectively.

Recourse was therefore taken to a "laboratory" eclipse. One actual eclipse negative was enlarged, and the outline of the umbra was used for a dodge on a full-moon negative, giving the eclipsed part a 40-per-cent overexposure in the print. The contour of the artificial umbra conforms to the eclipse negative, for I checked it carefully with a 5x magnifier.

HANS PFLEUMER
First Ave., RFD 14
New Brunswick, N. J.

This is a "laboratory" eclipse of the moon, made with a negative of the full moon combined in printing with a negative of a partial eclipse, by Hans Pfleumer.

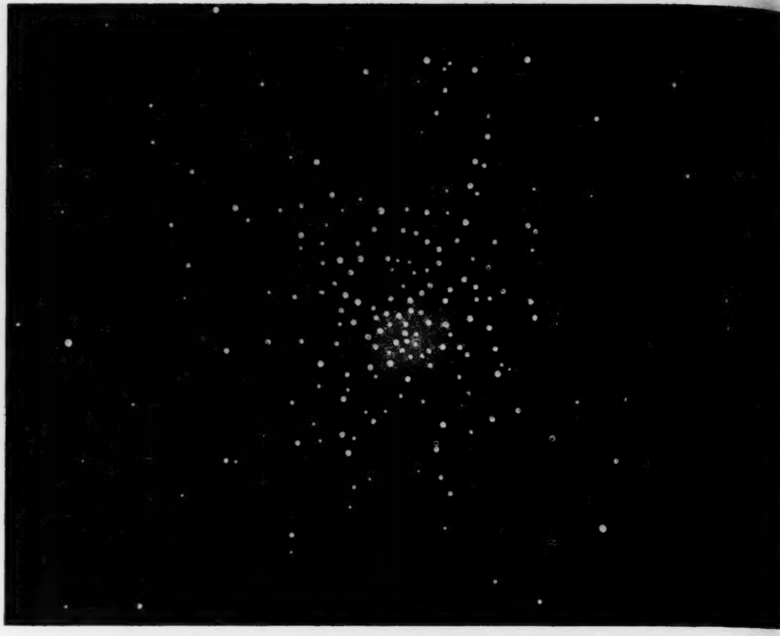
MOON PHASES AND DISTANCE

Last quarter	July 3, 22:03
New moon	July 11, 2:28
First quarter	July 19, 4:47
Full moon	July 26, 12:20
Last quarter	August 2, 3:16

July		Distance	Diameter
Perigee 1,	0^h	228,300 mi.	32′ 32″
Apogee 16,	15^h	251,600 mi.	29′ 31″
Perigee 28,	14^h	225,200 mi.	32′ 58″
August			
Apogee 13,	7^h	252,200 mi.	29′ 26″

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



An 1874 drawing of the telescopic appearance of the globular cluster in Hercules, by L. Trouvelot. Reprinted from the "Annals" of Harvard College Observatory.

DEEP-SKY WONDERS

THE GREAT Hercules globular cluster, NGC 6205, is better known as M13. It is at $16^h\ 39^m.9$, $+36°\ 33'$, is 23 minutes in diameter, of integrated photographic magnitude 6.78, visual magnitude 5.8 (from Holetschek), composite spectrum dF2, which accounts for the larger visual brightness. Its distance is about 30,000 light-years.

This cluster was discovered by Halley in 1715 over half a century before Messier inscribed it in his famous catalogue. Its naked-eye visibility makes it surprising that the cluster was not mentioned by the ancients. But since its discovery M13 has become the best known of the globulars. More professional papers have been written about it, more amateurs have turned their homemade telescopes to its easily accessible outlines, than any other of the class.

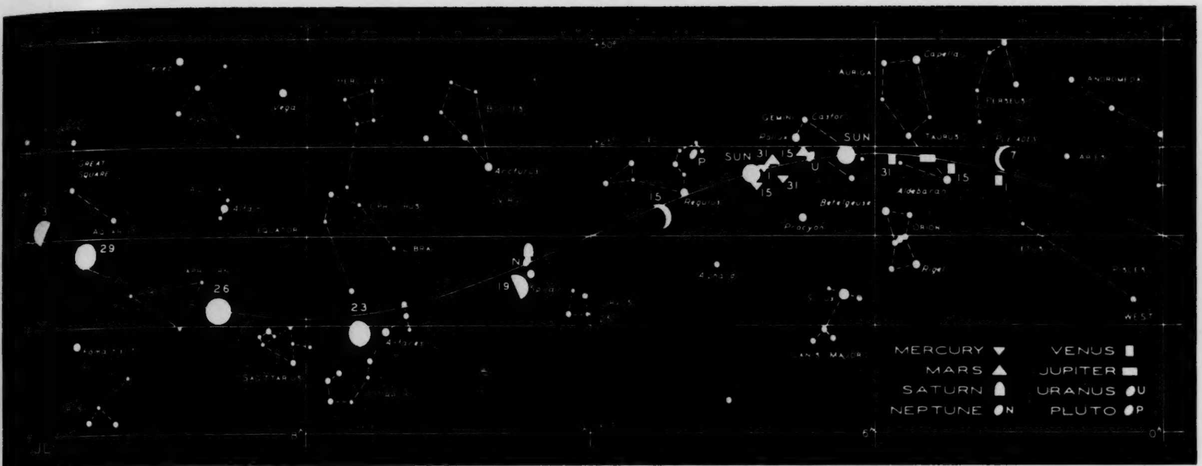
Early astronomers, like the amateur of today, were impressed with the somewhat irregular shape and the streams of stars radiating out from the center. The younger Herschel describes "hairy looking curvilinear branches," while the Earl of Rosse with his giant reflector detected three dark lanes in its interior. Secchi comments on the star streams radiating outward. Yet, as Shapley remarks, while short photographic exposures suggest these visual findings, increasing exposures drown them out and modern plates show a pretty even stellar distribution.

H. T. Sherman, of Wayzata, Minn., queries statements that the cluster is partially resolved in a 4-inch telescope. Most likely the answer lies in the fact that out

SUNSPOT NUMBERS

April 1, 43, 37; **2**, 50, 48; **3**, 55, 48; **4**, 51, 58; **5**, 36, 31; **6**, 34, 31; **7**, 46, 38; **8**, 37, 43; **9**, 26, 30; **10**, 15, 21; **11**, 4, 12; **12-17**, 0, 0; **18-19**, 0, 7; **20**, 0, 0; **21**, 1, 0; **22**, 12, 9; **23**, 22, 27; **24**, 32, 33; **25**, 40, 45; **26**, 54, 57; **27**, 54, 66; **28**, 44, 63; **29**, 45, 57; **30**, 44, 49. Means for April: 24.8 American; 27.2 Zurich.

Daily values of the observed mean relative sunspot numbers are given above. The first are the American numbers computed by Neal J. Heines from Solar Division observations; the second are the Zurich Observatory numbers.



near the edges of the globular the eye becomes aware of an unevenness of the background and tends to interpret this patchy appearance as individual stars. Also, tight groupings of two to four 13th-magnitude stars will certainly be interpreted by the eye as one brighter star.

While he observes M13, the amateur may try his luck at the virtually unknown galaxy nearby, NGC 6207, which lies 23′ north and $1^m.4$ east, a spiral 2.0 by 0.7 minutes of arc, of photographic magnitude 12.3 and visual magnitude 10.5. The galaxy, also known as Herschel 701[2], is usually almost forgotten in the excitement that M13 provides.

WALTER SCOTT HOUSTON

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

The sun. A partial eclipse of the sun occurs on July 11th, visible mainly in western Canada and the arctic regions. Greatest obscuration will be 20% of the sun's disk. Observers in Seattle, Vancouver, B. C., and Juneau, Alaska, will see a 2% to 3% eclipse just before sunset.

Mercury may be viewed in the evening sky the first week of July, after having passed eastern elongation on June 27th. It will be of the 1st magnitude, setting a little over one hour after the sun. Inferior conjunction with the sun occurs July 25th; the planet then enters the morning sky.

Venus, a morning-sky object, rises three hours before the sun in mid-month, appearing at magnitude −3.7. During July, the planet traverses all of Taurus, being in the northern region of the Hyades around the 15th. On the 22nd, Venus passes 1° 55′ south of Jupiter. Telescopically, Venus presents a disk 19″ in diameter, 61% illuminated on July 15th.

Mars enters the morning sky on July 8th, when it is in conjunction with the sun, and hence cannot be observed.

Jupiter will be in the morning sky not far from Venus during July. Conjunction of these two bright planets occurs on the 22nd, with Venus 1° 55′ south. Jupiter is moving eastward in Taurus, and shining at magnitude −1.6.

Saturn passes eastern quadrature with the sun on July 13th, setting just before midnight. Two days earlier, Saturn and Neptune are in conjunction for the third and final time for this series, with Saturn 53′ north. The pair is directly north of Spica in Virgo, with Saturn 5° north. Neptune is of the 8th magnitude and Saturn +1.0. The ring system of Saturn appears 12°.2 inclined to our line of view in mid-month, with the northern face visible.

Uranus passes conjunction with the sun on July 11th.

Neptune is at eastern quadrature on July 13th. Its conjunction with Saturn on the 11th is described above.

E. O.

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Vesta, 4, 6.3. July 22, 22:12.4 −18-03. Aug. 1, 22:06.1 −19-25; 11, 21:57.8 −20-50; 21, 21:48.5 −22-07; 31, 21:39.7 −23-07. Sept. 10, 21:32.5 −23-46.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1953.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

OCCULTATION PREDICTIONS

These predictions include a star fainter than 5.0, occulted during the Pleiades occultations on July 6-7. Refer to the chart, page 52, December issue.

July 6-7 **Eta Tauri** 3.0, 3:44.7 +23-57.7, 26, Im: **A** 7:06.7 +0.4 +1.5 64; **B** 7:11.8 +0.4 +1.6 58. Em: **A** 8:00.2 −0.1 +1.4 260; **B** 8:04.3 −0.1 +1.4 267; **C** 7:55.4 +0.1 +1.3 259; **D** 8:01.5 0.0 +1.3 270.

July 6-7 **23 Tauri** 4.2, 3:43.5 +23-48.2, 26, Em: **A** 7:29.2 +0.2 +1.5 246; **B** 7:33.9 +0.2 +1.5 251; **D** 7:32.6 +0.3 +1.4 254.

July 6-7 **27 Tauri m** 3.8, 3:46.4 +23-54.7, 26, Im: **A** 7:44.9 −0.2 +1.1 101; **B** 7:48.3 −0.1 +1.2 94; **C** 7:41.0 0.0 +0.9 102; **D** 7:46.2 +0.1 +1.2 91. Em: **A** 8:34.4 +0.2 +2.1 222; **C** 8:28.1 +0.3 +2.0 221; **D** 8:37.9 +0.2 +1.8 234; **E** 8:34.7 +0.3 +1.6 240.

July 6-7 **28 Tauri** 5.2, 3:46.4 +23-59.7, 26, Em: **C** 8:34.9 +0.1 +1.7 239; **D** 8:42.8 0.0. +1.6 250; **E** 8:38.3 +0.2 +1.3 257.

July 21-22 **Pi Scorpii** 3.0, 15:56.0 −25-58.8, 11, Im: **A** 1:46.9 −2.0 −0.5 91; **B** 1:43.4 −1.9 −0.4 88; **C** 1:39.0 −2.2 −0.4 97; **D** 1:32.7 −2.0 −0.1 94. Em: **A** 3:09.6 −1.6 −1.3 285; **B** 3:03.9 −1.6 −1.3 290; **C** 3:05.9 −1.9 −1.1 282; **D** 2:56.3 −1.8 −1.1 289; **E** 2:36.5 −2.1 −0.5 283; **F** 2:21.3 −2.8 +0.3 263.

August 2-3 **17 Tauri** 3.8, 3:42.1 +23-58.0, 23, Im: **H** 11:47.1 −2.4 −0.6 124; **I** 11:53.5 −0.9 +1.5 81. Em: **H** 12:27.7 +0.2 +4.2 192.

August 2-3 **q Tauri** 4.4, 3:42.4 +24-19.3, 23, Im: **H** 11:59.8 −0.8 +2.2 51.

August 2-3 **20 Tauri** 4.0, 3:43.0 +24-13.3, 23, Im: **H** 12:12.3 −1.4 +1.2 83.

August 4-5 **125 Tauri** 5.0, 5:36.8 +25-52.4, 25, Em: **I** 11:34.2 +0.3 +2.4 226.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	E	+91°.0,	+40°.0
B	+73°.6,	+45°.6	F	+98°.0,	+31°.0
C	+77°.1,	+38°.9	G	+114°.0,	+50°.9
D	+79°.4,	+43°.7	H	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

JULY METEORS

The period between July 21st and August 16th is undoubtedly the time when most meteor observing is done in the year. The Delta Aquarid shower extends from July 21st to August 1st, with maximum on July 28th. The famed Perseid shower begins in late July, but does not sharply increase in activity till August 7th. As the moon is full on July 26th, it will interfere with observations until the first few days of August.

The Delta Aquarid shower may have rates up to 30 per hour after midnight under favorable conditions. The meteors are usually slow, many with long paths and trains; most of the bright ones may be seen with a full moon in the sky.

E. O.

VARIABLE STAR MAXIMA

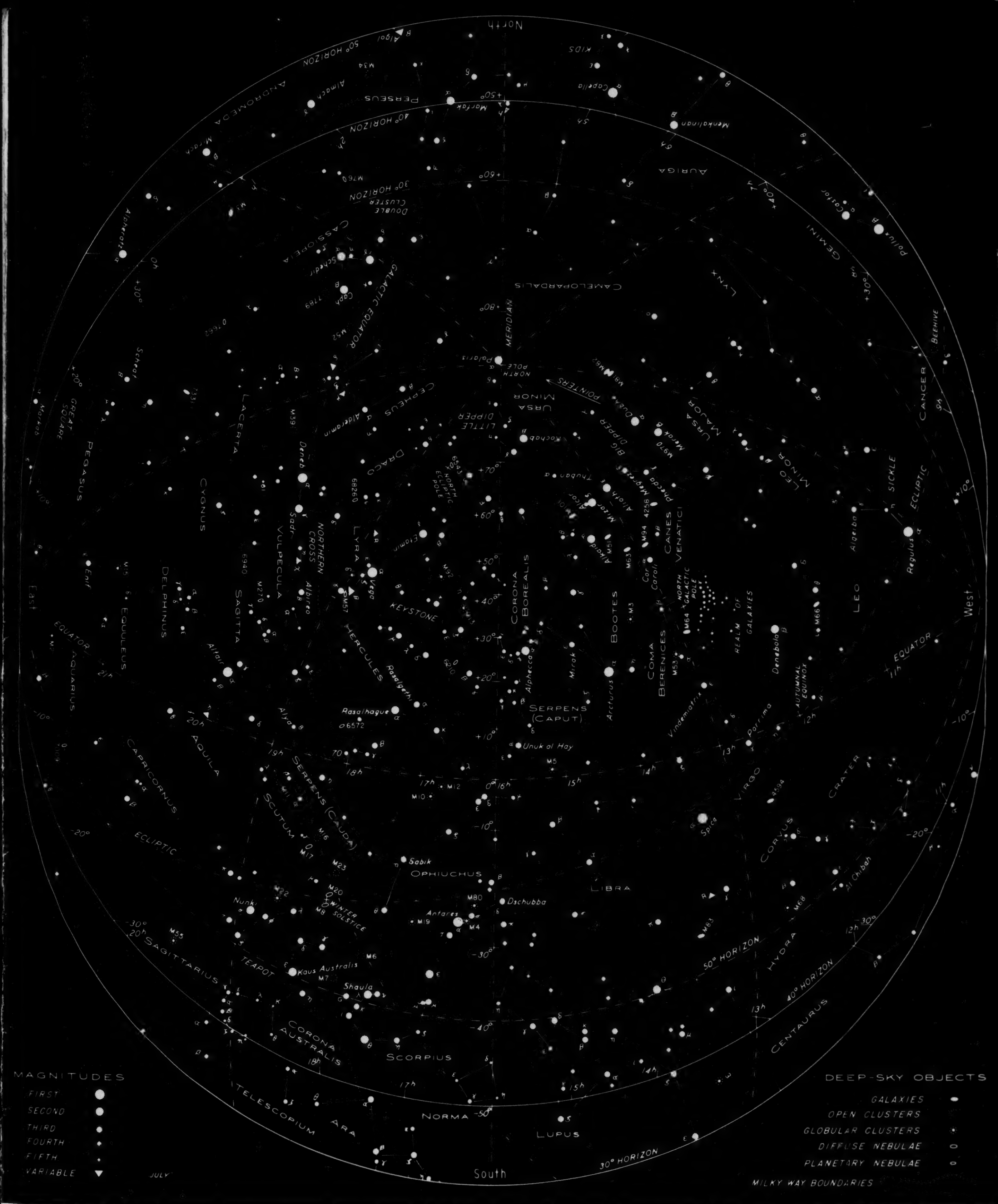
July 2, R Lyncis, 065355, 7.9; 4, S Gruis, 221**948**, 7.8; 21, R Carinae, 092**962**, 4.6; 21, T Herculis, 180531, 8.0; 26, V Monocerotis, 061**702**, 7.1.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

MINIMA OF ALGOL

July 3, 15:54; 6, 12:43; 9, 9:31; 12, 6:19; 15, 3:08; 17, 23:56; 20, 20:45; 23, 17:33; 26, 14:22; 29, 11:11. August 1, 8:00.

These minima predictions for Algol are taken from the 1953 **Handbook** of the Royal Astronomical Society of Canada.



STARS FOR JULY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively; also, at 7 p.m. and 6 p.m. on August 7th and 23rd. For other times, add or subtract ½ hour per week. When facing north, hold "North" at the bottom; turn the chart correspondingly for other directions. The projection (stereographic) shows celestial co-ordinates as circles.